Rapid Environmental Impact Assessment (REIA)
Pig Iron Plant
M/s. Sesa Industries Ltd., Amona, Goa

Sponsor: M/s Sesa Industries Ltd., Amona, Goa

National Environmental Engineering Research Institute
Nehru Marg, Nagpur- 440020

NEERI

ISO 9001 REGISTERED

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Foreword

Hon'ble High court of Bombay at Goa in Writ petition No. 243 of 2008 filed by Secretary, Amona Bachao Andolan Vs. The state of Goa and eight other respondents, directed National Environmental Engineering Research Institute (NEERI), Nagpur to conduct Rapid Environmental Impact Assessment study of Pig Iron Plant of M/s Sesa Industries Ltd. (SIL), with regard to release of graphite particulate emissions from pig iron plant and to consider all aspects of the matter including hazards to human health as well as life in general.

Accordingly, NEERI monitored workplace fugitive emissions around blast furnace and its impact on ambient air quality in surrounding villages with respect to Respirable Particulate Matter (RPM), Suspended Particulate Matter (SPM), Sulphur Dioxide (SO_2) & Nitrogen Dioxide (NO_2) and checked its compliances / non-compliance status with respect to GSPCB/CPCB norms. In order to study impact of graphite particulate emissions on human health, various parameters viz. lung function test, blood & urine examination, chest X-ray etc., indicating health status of SIL employees as well as that of nearby villagers, were investigated.

Based on primary & secondary data as well as field observations, conclusions have been drawn. Further, to minimize the impact, air environment management plan has been delineated, and appropriate recommendations are presented. The co-operation and assistance, rendered by M/s Sesa Industries Ltd. in conduction of this study, is gratefully acknowledged.

(Dr.T. Chakrabarti)

Nagpur

Dec, 2008

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Introduction

Chapter-I

1.0 Introduction

1.1 Preamble

Hon'ble High court of Bombay at Goa in Writ petition No. 243 of 2008, filed by Secretary, Amona Bachao Andolan Vs. The state of Goa through Chief Secretary and eight other respondents, directed National Environmental Engineering Research Institute (NEERI), Nagpur to conduct "Rapid Environmental Impact Assessment Study on Pig Iron Plant of M/s Sesa Industries Ltd. (SIL), Amona, Goa" with regard to release of graphite particulate emissions in the atmosphere and its impact on surrounding areas. Further, the Hon'ble High court directed NEERI to consider all aspects of the matter including hazards to human health as well as life in general, in the surrounding areas due to graphite particulate emissions from pig iron plant so as to indicate the permissible limit of graphite particles for the purpose of ambient air quality and submit the report directly to Hon'ble High court by Nov.15, 2008.

1.2 Objectives of the Study

Assessment of graphite particulate emissions released from Pig Iron Plant and its impact on human health in the surrounding areas, if any and life in general and to recommend measures to minimize graphite particulate emissions and its likely impact.

1.3 Scope of Work

- Monitor fugitive graphite particulate emissions in the work zone of Pig Iron Plant.
- Assessment of graphite particulate pollution in ambient air of the surrounding air basin in terms of Respirable & Suspended Particulate Matter (RPM & SPM) levels and gaseous pollutants in terms of Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and compliance checks with the regulatory standards.
- Thorough investigations on health risk assessment through questionnaires and blood as well as urine samples drawn from shop floor workers as well as from exposed population in nearby villages.
- Identification of adverse impacts on human health, if any and life in general of the exposed population.
- Conclusions and recommendations.

- Delineate air environment management plan to be implemented to minimize adverse impacts, if any.

1.4 Execution of Project Activities: Work Plan

The project work was planned to be executed in following sequence:

- Preliminary visit to the site to collect secondary data / information on sources of dust (graphite particulate) generation in the pig iron plant of SIL, Amona ,Goa.
- Selection of AAQ monitoring sites around the plant at Amona, considering the views/suggestions of concerned Grampanchayat, NGO's, etc.
- Monitoring of fugitive particulate emissions in the work (blast furnace) zone of pig iron plant and ambient air quality in terms of Respirable and Suspended Particulate Matter (RPM & SPM), Sulphur Dioxide (SO_2) and Nitrogen Dioxide(NO_2) at identified sites and check compliance with ACGIH/OHSA for work place standards and GSPCB / CPCB for AAQ standards.
- Health status of SIL employees as well as that of nearby villagers (Amona & Navelim) in terms of various parameters viz. lung function test, blood & urine examination, chest X-ray etc. was investigated.
- Conclusions of the study.
- Recommend an air environment management plan to reduce graphite particulates emissions for minimizing the adverse health impacts, if any and report submission.

1.5 Report Outlay

The second chapter of report comprises brief description of pig iron manufacturing process and production details in terms of material balance of raw materials processed and product / byproducts manufactured during the study period. Chapter-III assesses emissions at work place and its impact on surrounding air basin in terms of RPM and SPM, SO_2 and NO_2 along-with meteorological data on wind speed, wind direction. Investigations on health status of employees working in pig iron plant as well as that of villagers residing in nearby villages, Amona and Navelim are covered in Chapter-IV. Conclusions of this study have been drawn in Chapter-V and Chapter-VI provides recommendations for implementation of air environment management plan to minimize adverse impacts, if any of pig iron plant emissions.

Chapter II

Pig Iron Manufacturing Process
and
Production Details

Chapter II

2.0 Pig Iron Manufacturing Process and Production Details

2.1 Pig Iron Manufacturing Process at Sesa Industries Ltd., Amona, Goa

2.1.1 Raw materials required to produce pig iron are:

1. Iron Ore
2. Metallurgical Coke
3. Limestone
4. Dolomite

2.1.2 Iron ore and coke screening unit

The iron ore is transported to plant through trucks / tippers as shown in **Plate 2.1**.The iron ore from raw material hoppers is screened at the screening plant (Plant 5). The iron ore required in blast furnace is of 10-30 mm size. The fluxes vis-à-vis limestone and dolomite are unloaded by the hydraulic truck unloader into the hoppers. The generated dust during unloading is suppressed with fine water sprays. From the hoppers these fluxes are transported by tippers / trucks at designated place in the raw material yard. The hoppers, where the coke is unloaded are fitted with dry fog de-dusting system as shown in **Plate 2.2**. In blast furnace 20-60 mm metallurgical coke is required, which is procured from Sesa Goa's Met Coke division

2.1.3 Met coke production process

Coal from vessels/ship is transported to the Jetty of Sesa Goa Limited (Met Coke Division) by barges, unloaded by Jetty unloaders and transported to the coal shed (**Pate 2.3**) by trucks and conveyors. Coal from the coal shed is blended, crushed and transported to the bin at the ovens or at compacting station. Charging car collects the coal from the bin or coal cake from compacting station and feeds to the ovens. Immediately after charging, the coal absorbs heat from the surrounding refractory and thus, evolved volatile matter is burnt. Air for combustion of volatile matter is supplied through the openings in doors and in the sole flues. Coke after readiness is pushed by the ram pusher into the waiting hot coke car. The red hot coke is then quenched in the quench tower, passed through the coke cutter and the screens for separating various size fractions. Blast furnace coke is directly supplied to pig iron plant coke shed by trucks. Particulate emissions are suppressed by high pressure jet spray as shown in **Plate 2.4**.

Plate 2.1: Loading of iron ore for transportation to plant

Plate 2.2: Water spray at coke unloading hopper at SIL, Amona ,Goa

Plate 2.3: Coal Shed for coal storage

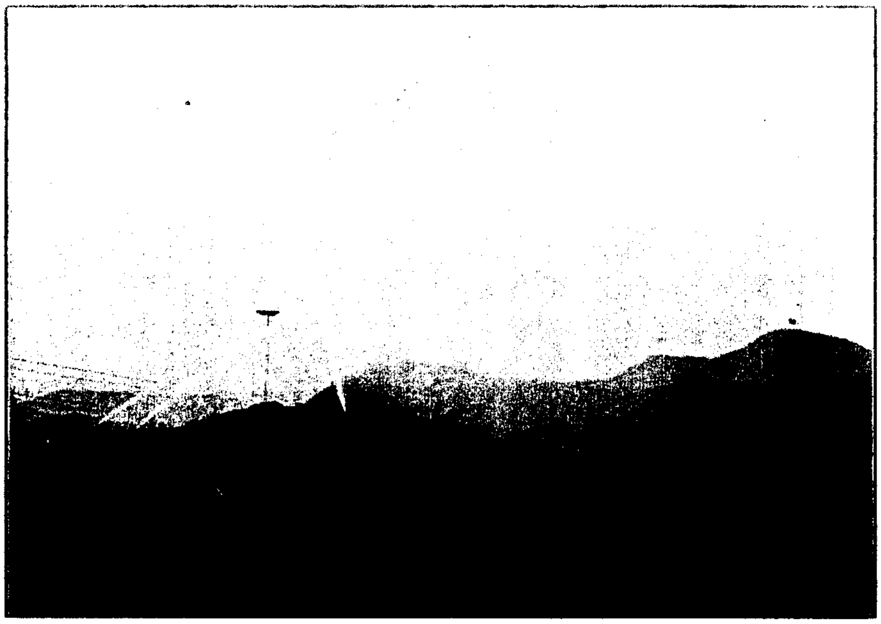


Plate 2.4: High Pressure jet spray in operation at coke yard

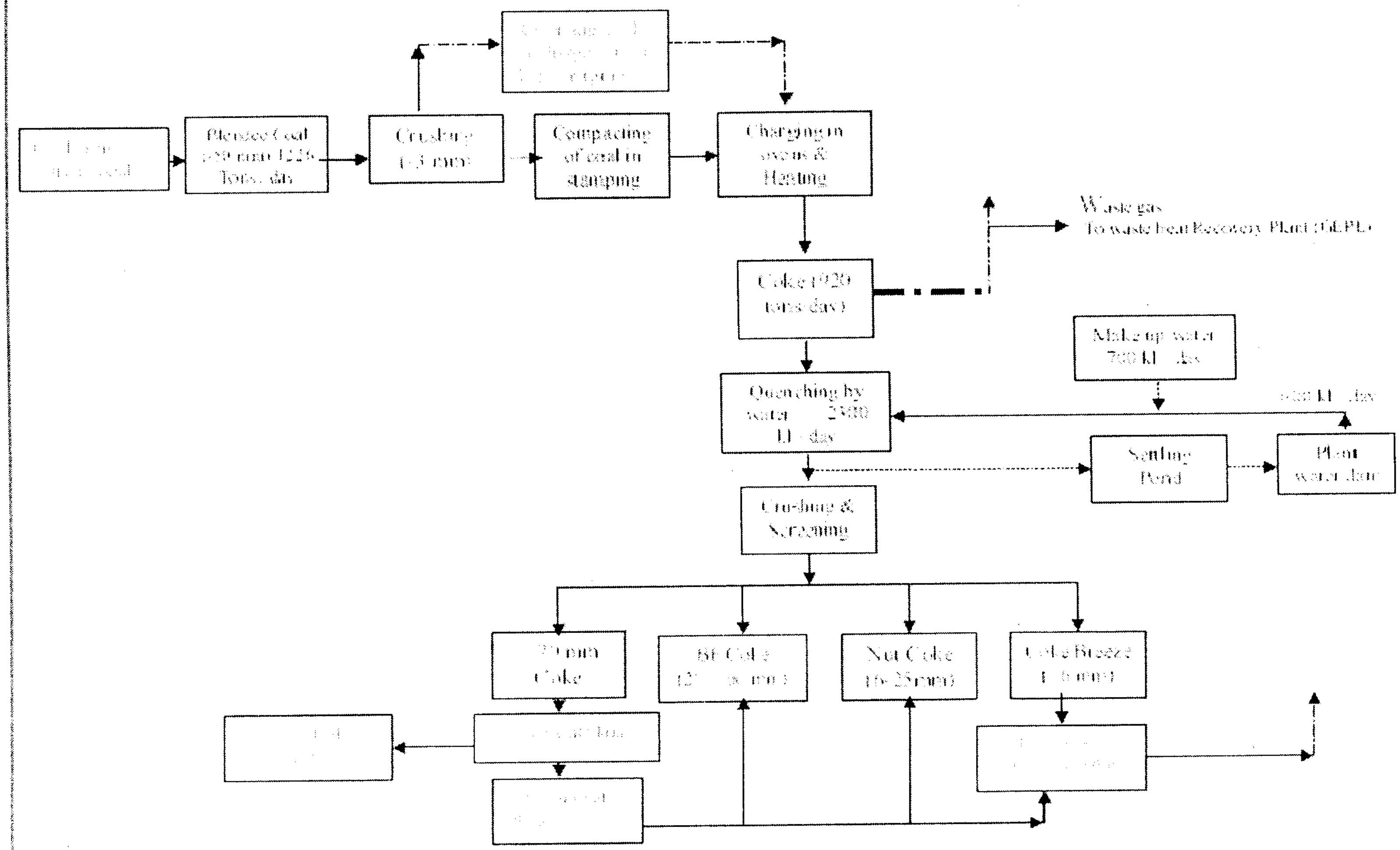


Fig. 2.1: PROCESS FLOW DIAGRAM OF COKE PLANT (METCOKE DIVISION)

SESA GOA LTD, Amona, Bicholim, Goa

All other grades are stockpiled at coke stockyard, Foundry grade coke is again processed through the screens of plant 6 & 7 at coke stockyard as per customer requirements. Most of the coke fines (below 6 mm) are then dried and ground to fine mesh in Coke Drying and Grinding Plant (CDGP) and charged back into the oven along with the coal. The other grades are sold in the market.

The quench water is circulated through the settling pond and the plant water dam. The coke fines in the quench water stream are collected from the settling pond and are sold as a product. Make up water is added as per requirement and, there is no water effluent generation.

The combustibles in the volatile matter burn in the ovens and in the flues. The resulting flue gases are supplied to M/s Goa Energy Pvt. Ltd. (GEPL) for recovering heat to generate power. The flue gases if not connected to GEPL, are let out through the stack which conforms to the stack gas emission norms. The GEPL established by Videocon International is operating a 30 MW waste heat recovery based power plant based on waste heat from Met Coke Plant and BF gas from Pig Iron Plant of Sesa group. This project has been registered as a CDM (Clean Development Mechanism) project at United Nation's Framework Convention on Climate Change (UNFCCC) under SESA Goa ltd. and is earning benefits of carbon credits. As of now around 90,000 Certified Emission Reduction (CER) have been accrued and UNFCCC has accorded clearance to trade off about 43,000 CER's.

2.1.4 Blast furnace unit:

The process in the blast furnace consists of charging iron ore and coke along with fluxes from the furnace top and dust particle arrested by dry fog spray system (**Plate 2.5**) and the coke is transported through closed conveyer belt as shown in the **Plate 2.6.** The blowing preheated air from the bottom of the furnace for burning the coke and providing the heat/gas required for reducing and melting iron ore. The reducing gases resulting from the combustion of the coke move in counter current through the furnace at high temperature and transfer their sensible heat to the descending charge and reduce the charge. The reduced Iron reaching the bosh starts to melt due to the high temperature and drops into the hearth of the furnace. The impurities in the ore get combined with fluxes and thus slag is formed. Both metal and slag gets accumulated in hearth and is taken out from the hearth through tap-hole at regular intervals.

A typical process flow sheet of pig iron production is presented in **Fig. 2.2.** During the tapping, the fumes and graphite particulates are captured by runner hood fitted above the runner which is connected to bag house assembly through ID fan. The material balance across the blast furnace used for pig iron production is presented in the **Fig. 2.3**.

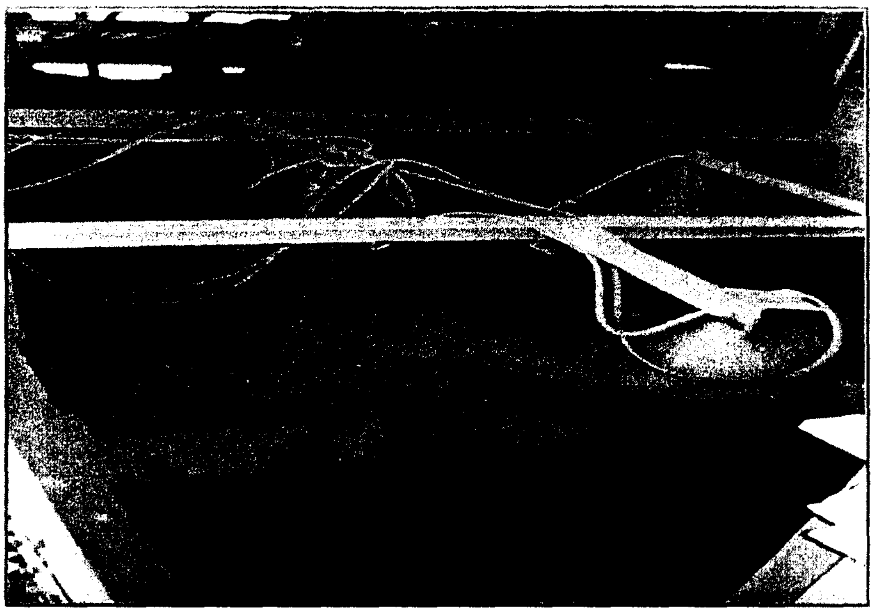


Plate 2.5: Dry fog spray on sizer plant screen of BF-I

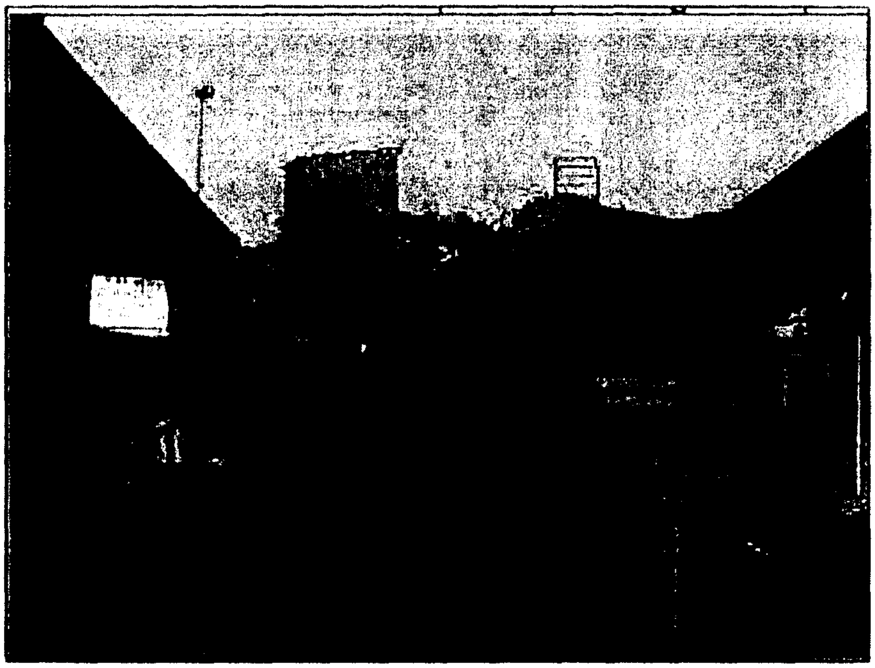


Plate 2.6: Coke conveyer covered with semi-circular hoods to prevent fugitive particulate emissions

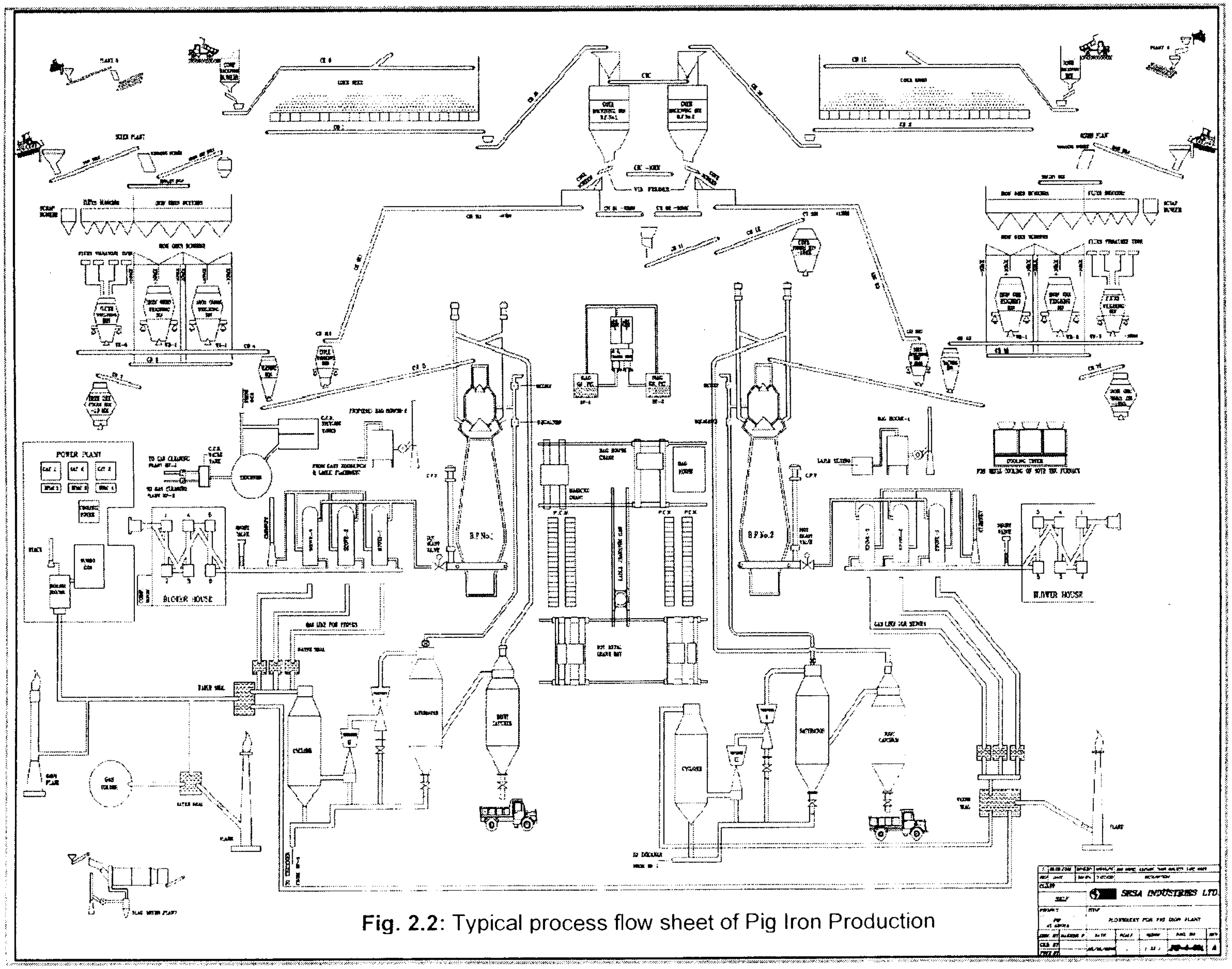


Fig. 2.2: Typical process flow sheet of Pig Iron Production

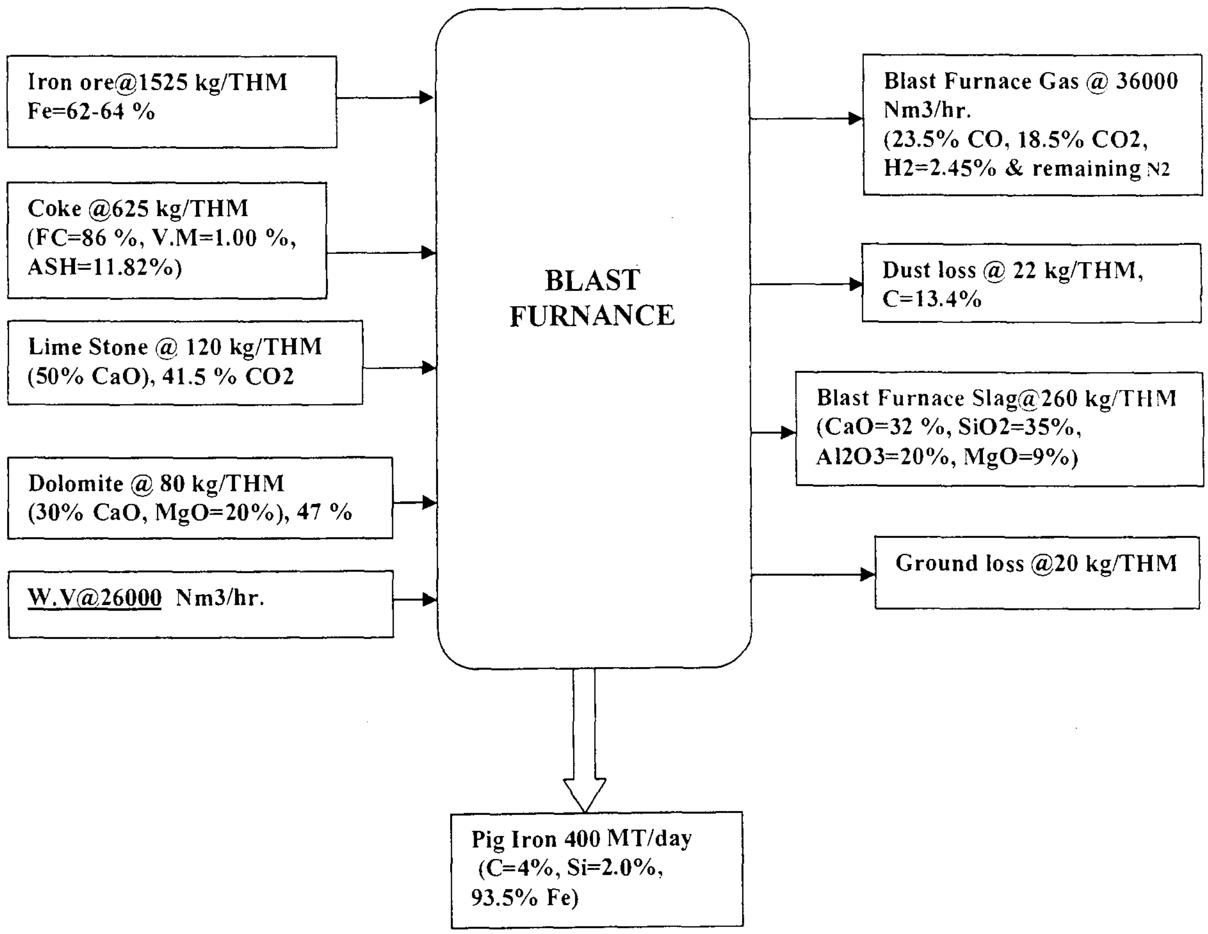


Fig. 2.3 Material balance across the blast furnace used for pig iron production

2.1.5 Product purification and dust control options:

Some hot metal is de-sulphurized to produce a special grade of pig iron. A de-sulphurisation de-dusting system is fabricated with a snorkel hood, in which the dust generated during de-sulphurisation is collected. The ladles are cleaned of metal jams, in a special chamber, closed on all sides. The ID fan sucks the dust generated during cleaning and passes it through the bag house. The air is filtered out in the bag house and the dust is collected in the hopper bags. The air blast, which goes into the blast furnace, is heated by six (6) nos. of Hot Blast Stoves, using blast furnace gas as fuel. Altogether there are six stoves. Three stoves per furnace, out of which one is on blast and other two are on gas. A chimney of 45-metre height is provided to let out the combustion product per set of three stoves. Also an air-preheater is installed, in which the hot flue gases are used to pre heat the cold air blast.

2.1.6 Product and by-product:

From the hot metal, pig iron is manufactured by pouring into the moulds (**Plate 2.7**) and cooling with water. The slag is granulated by using high jet of water (**Plate 2.8**). The blast furnace slag is then dried in a slag drier plant. In slag drier plant, slag is dried in a rotary kiln, using blast furnace gas as fuel. The flue gases are cleaned using water scrubber and cyclone and let through a stack attached to slag drier plant. The slag is then sold to cement industries.

The blast furnace gas, after cleaning through dust catcher, scrubber, ventury scrubbers is used as fuel in Hot Blast Stoves, slag drier plant and five TPH boilers. Remaining gas is transported to waste heat recovery based power plant of M/s GEPL, using about 1.5 km pipeline. Three flare stacks are provided to flare off the excess gas in case of emergency in the power plant. Thus, there are no flue gases emissions in normal operation.

The water used in the plant is either for cooling or gas cleaning purpose. The shell cooling, cooling plates and valve cooling water is re-used by cooling down in the cooling towers. The slag granulation water is re-used by settling in the two pond system. The water used for the gas cleaning plants vis-à-vis saturators & ventury scrubbers are re-used by settling in two pond and thickener system.

Pig iron produced is stock piled cast-wise in stockyard, loaded manually into trucks and transported by roads and sea. The chips and gholis are screened at screening plant (Plant 8), to make this waste material into saleable fraction.

2.2 Quantities of Materials Handled in Pig Iron Production

The various types of materials consumption viz. Iron ore, Coke, Dolomite, Limestone and product / byproduct viz. Pig iron, Slag, Blast furnace gas (BFG) production details during Oct 1-21, 2008 are described below.

Plate 2.7: Pig iron manufacturing by pouring hot metal into the moulds.

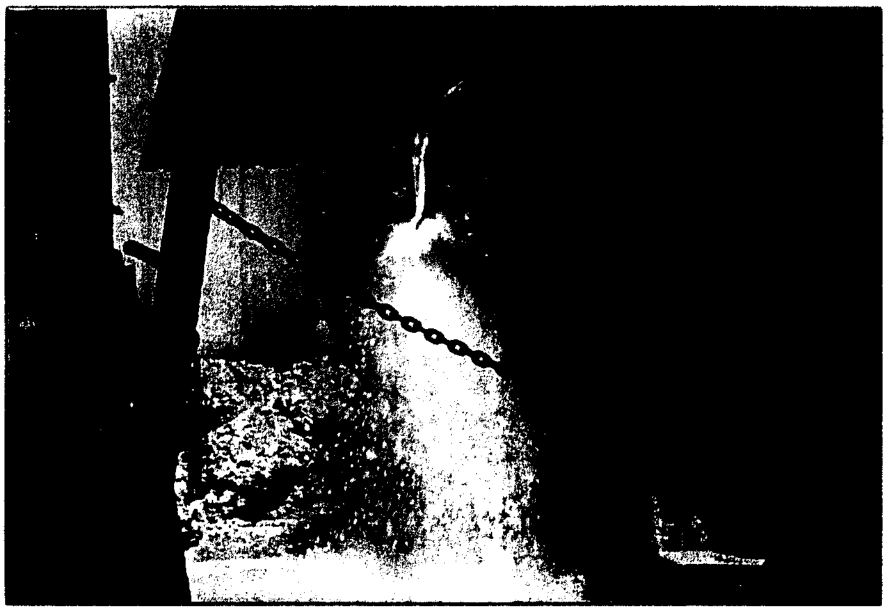


Plate 2.8: Slag granulation using high jet of water.

2.2.1 Iron ore

As shown in **Table 2.1** Iron ore is foremost material used for pig iron production. The total quantity used in BF-I and BF-II is 24,034,733 (Kg) during Oct 1- 21, 2008 with a daily average of 11, 44,511 Kilogram Per Day (KgPD) iron ore consumption.

Table 2.1: Iron ore consumption (Kg)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	328,791	649,711
October 2, 2008	630,431	145,227
October 3, 2008	630,170	376,394
October 4, 2008	634,738	523,748
October 5, 2008	546,270	609,441
October 6, 2008	640,832	607,050
October 7, 2008	626,005	642,477
October 8, 2008	621,727	640,616
October 9, 2008	640,492	621,207
October 10, 2008	477,885	611,497
October 11, 2008	362,671	462,464
October 12, 2008	323,885	643,735
October 13, 2008	641,484	650,443
October 14, 2008	622,953	622,018
October 15, 2008	602,603	639,822
October 16, 2008	615,417	627,883
October 17, 2008	419,189	622,179
October 18, 2008	604,011	618,999
October 19, 2008	633,007	627,716
October 20, 2008	633,260	602,001
October 21, 2008	639,834	614,450
Total (Kg)	**1,18,75,655**	**1,21,59,078**
Average (KgPD)	565,507	579,004
Total, (Kg) (BF-I+BF-II)	**2,40,34,733**	
Daily Average (BF-I+BF-II, KgPD)	**11,44,511**	

Source: Data provided by SESA Industries Ltd., Amona, Goa

2.2.2 Met coke

Table 2.2 indicates that total met coke consumed during Oct 1-21, 2008 is 98,85,772 Kg in both of the blast furnaces (BF-I & BF-II) with daily average consumption of 470,751 KgPD.

Table 2.2: Met Coke consumption (Kg)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	125,474	244,342
October 2, 2008	242,117	244,342
October 3, 2008	243,501	144,357
October 4, 2008	247,529	229,171
October 5, 2008	213,208	237,144
October 6, 2008	249,167	229,071
October 7, 2008	245,653	242,514
October 8, 2008	244,000	238,829
October 9, 2008	250,996	240,780
October 10, 2008	243,833	238,643
October 11, 2008	238,031	247,086
October 12, 2008	244,417	244,961
October 13, 2008	244,050	245,444
October 14, 2008	234,065	238,493
October 15, 2008	236,885	250,588
October 16, 2008	236,417	240,686
October 17, 2008	235,786	237,758
October 18, 2008	226,864	245,493
October 19, 2008	240,181	245,598
October 20, 2008	242,360	234,892
October 21, 2008	242,927	238,119
Total (Kg)	**49,27,461**	**49,58,311**
Average (KgPD)	234,641	236,110
Total (BF-I+BF-II) (Kg)	**98,85,772**	
Daily Average (BF-I+BF-II, KgPD)	**470,751**	

Source: Data provided by SESA Industries Ltd., Amona

2.2.3 Nut coke

The total nut coke consumed in BF-I and BF-II is 379,794 Kg as shown in **Table 2.3** while the daily average nut coke used per day is 18,085 KgPD.

Table 2.3: Nut Coke consumption (Kg)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	3,252	12,380
October 2, 2008	6,183	12,153
October 3, 2008	6,268	7,244
October 4, 2008	6,278	11,557
October 5, 2008	5,456	12,201
October 6, 2008	6,488	12,047
October 7, 2008	6,279	12,237
October 8, 2008	6,175	12,132
October 9, 2008	6,431	12,431
October 10, 2008	6,150	12,129
October 11, 2008	6,147	12,649
October 12, 2008	6,247	12,600
October 13, 2008	6,250	12,750
October 14, 2008	6,041	12,605
October 15, 2008	6,132	12,906
October 16, 2008	6,110	12,358
October 17, 2008	6,180	12,358
October 18, 2008	5,817	12,424
October 19, 2008	6,263	12,488
October 20, 2008	6,218	11,864
October 21, 2008	6,063	11,853
Total (Kg)	**126,428**	**253,366**
Average (KgPD)	6,020	12,065
Total (BF-I+BF-II) (Kg)	**3,79,794**	
Daily Average (BF-I+BF-II, KgPD)	**18,085**	

Source: Data provided by SESA Industries Ltd., Amona

2.2.4 Limestone

The total quantity of limestone used in BF-I and BF-II is 2,173,423 Kg (**Table 2.4)** while daily average limestone consumption is 103,497 KgPD.

Table 2.4: Limestone consumption (Kg)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	28,347	52,870
October 2, 2008	54,853	50,867
October 3, 2008	55,150	30,662
October 4, 2008	55,916	47,412
October 5, 2008	48,659	49,472
October 6, 2008	56,844	48,439
October 7, 2008	56,005	50,295
October 8, 2008	55,010	51,663
October 9, 2008	56,682	54,456
October 10, 2008	53,681	54,566
October 11, 2008	51,138	53,876
October 12, 2008	55,009	54,572
October 13, 2008	56,360	53,252
October 14, 2008	54,587	51,272
October 15, 2008	54,715	52,289
October 16, 2008	52,657	50,861
October 17, 2008	53,169	50,708
October 18, 2008	50,562	51,341
October 19, 2008	54,665	52,828
October 20, 2008	55,304	48,943
October 21, 2008	55,300	48,166
Total (Kg)	**11,14,613**	**10,58,810**
Average (KgPD)	53,077	50,420
Total (BF-I+BF-II) (Kg)	**21,73,423**	
Daily Average (BF-I+BF-II, KgPD)	**103,497**	

Source: Data provided by SESA Industries Ltd., Amona

2.2.5 Dolomite

Table 2.5 indicates the dolomite consumption during Oct 1-21, 2008. The daily average quantity of dolomite used is, 65,010 KgPD and the total quantity of dolomite used in BF-I and BF-II is 13, 65,212 Kg.

Table 2.5: Dolomite consumption (Kg)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	17,616	33,583
October 2, 2008	34,096	28,127
October 3, 2008	34,142	15,673
October 4, 2008	34,535	24,904
October 5, 2008	30,115	26,081
October 6, 2008	35,269	25,442
October 7, 2008	34,487	26,427
October 8, 2008	32,166	29,481
October 9, 2008	32,485	33,611
October 10, 2008	32,895	33,976
October 11, 2008	32,100	34,718
October 12, 2008	36,309	34,319
October 13, 2008	37,873	35,932
October 14, 2008	36,718	33,129
October 15, 2008	36,818	33,585
October 16, 2008	35,112	32,552
October 17, 2008	35,446	32,292
October 18, 2008	34,001	32,910
October 19, 2008	38,189	35,159
October 20, 2008	38,122	33,379
October 21, 2008	37,945	33,493
Total (Kg)	**716,439**	**648,773**
Average (KgPD)	34,116	30,894
Total (BF-I+BF-II) (Kg)	**13,65,212**	
Daily Average (BF-I+BF-II, KgPD)	**65,010**	

Source: Data provided by SESA Industries Ltd., Amona

2.2.6 Pig iron

The total pig iron produced during Oct. 1-21, 2008 is 16,872 MT **(Table 2.6)** and the daily average production is 804 MTPD.

Table 2.6: Pig Iron Production (MT)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	216	432
October 2, 2008	414	402
October 3, 2008	415	248
October 4, 2008	414	378
October 5, 2008	362	401
October 6, 2008	422	397
October 7, 2008	413	418
October 8, 2008	410	416
October 9, 2008	421	409
October 10, 2008	415	400
October 11, 2008	419	420
October 12, 2008	426	423
October 13, 2008	421	426
October 14, 2008	409	407
October 15, 2008	395	419
October 16, 2008	409	413
October 17, 2008	409	409
October 18, 2008	394	408
October 19, 2008	418	417
October 20, 2008	414	398
October 21, 2008	419	399
Total (MT)	**8,432**	**8,440**
Average (MTPD)	402	402
Total (BF-I+BF-II) (MT)	**16,872**	
Daily Average (BF-I+BF-II, MTPD)	**804**	

Source: Data provided by SESA Industries Ltd., Amona

2.2.7 Blast furnace gas (BFG)

As shown in **Table 2.7** the total blast furnace gas produced as a byproduct gas during Oct. 1-21, 2008, is 3,43,64,260 Nm^3 with a daily average of 16,36,393 Nm^3/day. The byproduct gas is sold to M/s GEPL, Goa for power generation.

Table 2.7: Blast Furnace Gas (BFG) Production (Nm^3)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	433,100	845,540
October 2, 2008	843,700	870,150
October 3, 2008	846,100	548,470
October 4, 2008	846,300	822,420
October 5, 2008	738,700	861,220
October 6, 2008	846,400	843,590
October 7, 2008	836,000	876,680
October 8, 2008	823,300	855,130
October 9, 2008	860,400	879,280
October 10, 2008	848,000	846,610
October 11, 2008	826,900	872,670
October 12, 2008	821,400	869,020
October 13, 2008	828,300	869,160
October 14, 2008	818,300	839,130
October 15, 2008	784,500	863,980
October 16, 2008	809,300	858,460
October 17, 2008	813,600	824,870
October 18, 2008	770,700	833,940
October 19, 2008	794,700	832,240
October 20, 2008	810,900	823,150
October 21, 2008	800,900	827,050
Total (Nm^3)	**1,68,01,500**	**1,75,62,760**
Average (Nm^3/D)	800,071	836,322
Total (BF-I+BF-II) (Nm^3)	**3,43,64,260**	
Daily Average, Nm^3/D (BF-I+BF-II)	**16,36,393**	

Source: Data provided by SESA Industries Ltd., Amona

2.2.8 Slag

Slag generated from the blast furnace is sold to cement industry as a byproduct **Table 2.8,** shows the slag production details where the total slag produced during Oct 1-21, 2008, is 4,388 MT and the daily average slag production from both blast furnaces is 209 MTPD.

Table 2.8: Slag Production (MT)

Date	Quantity BF-I	Quantity BF-II
October 1, 2008	57	105
October 2, 2008	109	99
October 3, 2008	108	58
October 4, 2008	116	95
October 5, 2008	98	95
October 6, 2008	112	98
October 7, 2008	109	101
October 8, 2008	105	105
October 9, 2008	109	104
October 10, 2008	106	111
October 11, 2008	105	111
October 12, 2008	109	112
October 13, 2008	112	109
October 14, 2008	107	103
October 15, 2008	107	109
October 16, 2008	104	106
October 17, 2008	107	107
October 18, 2008	105	108
October 19, 2008	120	113
October 20, 2008	114	101
October 21, 2008	115	103
Total (MT)	**2,231**	**2,157**
Average (MTPD)	106	103
Total (BF-I+BF-II)	**4,388**	
Daily Average (BF-I+BF-II, MTPD)	**209**	

Source: Data provided by SESA Industries Ltd., Amona.

2.3 Summary of different types of material consumption and product / byproduct generation

The percent contribution of major types of raw materials during Oct 1-21, 2008 is shown in **Fig. 2.4.** Component wise break-up of raw materials is 63.5% iron ore, 26.1% met coke, 5.7 % limestone, 3.6 % dolomite and 1% nut coke consumed per day. **Fig. 2.5** shows average percentage of pig iron (79.4%) and slag (20.6%) production during study period in SIL, Amona, Goa.

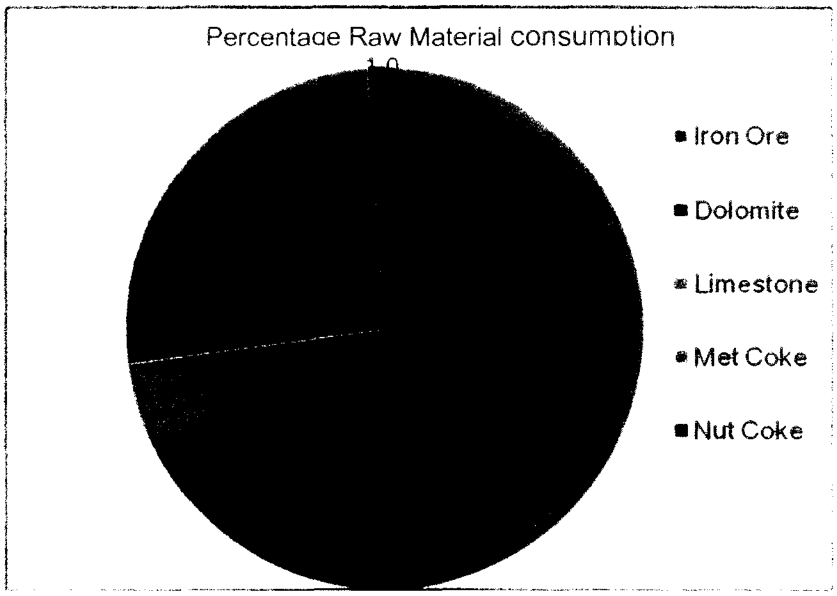


Fig. 2.4:- Percentage Raw Material consumption

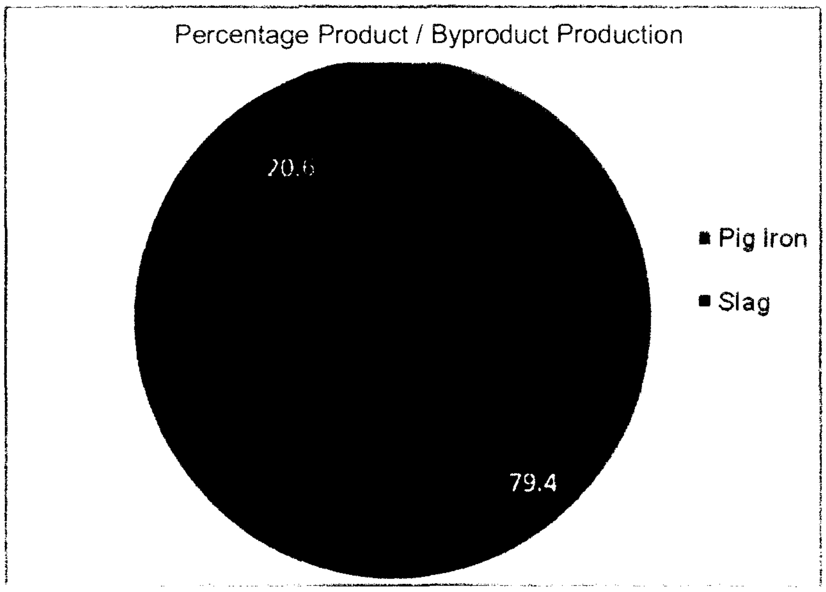


Fig. 2.5:- Percentage Product / Byproduct Production

Source: Data provided by SESA Industries Ltd., Amona, Goa.

Chapter III

Particulate Emissions at Work Place Environment and It's Impact on Surrounding Air Quality

3.0 Particulate Emissions at Work Place Environment and Its Impact on Surrounding Air Quality

In pursuant to the directives of Hon'ble High court of Bombay at Goa in Writ petition No. 243 of 2008, it was necessary to set-up effective monitoring network to asses levels of air pollutants as a result of fugitive emissions generated during pig iron manufacturing unit operations in work place environment as well as ambient air quality (AAQ) monitoring stations in villages around SESA Industries Ltd. (SIL), Amona, to assess the impact of particulate fugitive emissions generated due to various material handling and production activities, on the surrounding air basin within 10 km aerial distance.

3.1 Sources of Particulate Pollution

Besides natural sources, anthropogenic sources such as material transfer operations and evolution of graphite particulates during Pig Iron production process are the prominent sources of particulate pollution in the SESA Industries Ltd., Amona.

Sources of particulate emissions can be classified into following major groups, namely:

1. Dust generation due to unloading/ loading and stacking of iron ore in open space.
2. Vehicular movements during raw material/ product & byproduct transportation.
3. Material transfer and screening operations.
4. Charging of raw material into blast furnace through closed circuit conveyer system.
5. Graphite particulate generation while pouring of hot iron metal into ladles.

Graphite particulate emissions being the major issue in writ petition no. 243 of 2008, consideration of sources of graphite emissions are important. Consequent to reduction in solubility of carbon in molten hot metal due to sudden temperature drop during hot metal tapping from blast furnaces, graphite particles are evolved / generated. Graphite particulate emissions start as soon as molten hot metal flows through main runner into the ladle during tapping and then pouring of hot metal into continuously moving mould assembly. The possible emission sources of graphite flakes are listed below -

1. Main runner and ladle in cast house while tapping the hot metal from the furnace.
2. PCM runner and ladle while pouring the metal.
3. Bag house and its cleaning.
4. In the crane bay while cleaning with anchor.

3.1.1 Particle size fractionation of Graphite flakes / particles

In order to find out the percentage of various size fractions, graphite dust was collected from the bag filter and separated into magnetic / nonmagnetic components. Further, magnetic as well as non magnetic components of graphite dust are processed in particle size analyzer. Typical particle size fractionation analysis of graphite dust collected from Bag Filter is presented in **Table 3.1.** The data in the table indicates that around 90% of the graphite particles generated, being less than 100 μm, remain suspended of which respirable fraction (<10μm) is around 5% while the particles capable of entering into lungs (<2.5μm) are around 1%.

Table 3.1: Particle Size Distribution of Graphite Particles

Particle diameter (μm)	Cumulative Value %	
	Non-magnetic particles	Magnetic particles
2.5	1	1
10	5.5	5
15	9	8.5
50	48	43
100	92	90

3.2 Materials & Methods

Detailed monitoring and analytical protocols for work place environment as well as air quality for various parameters (RPM, SPM, SO_2 and NO_2) are given in **Table 3.1**. ACGIH /OSHA indoor regulatory limit and CPCB regulatory standards for ambient air quality in terms of particulate pollutants are given in **Annexure-I** and **Annexure-II** respectively.

Table 3.1a: Techniques used for Monitoring and Analysis

Environmental component	Sampling duration	Parameter	Unit		Technique
			WEM	AAQ	
1. Work Place Emissions Monitoring (WEM)	8 Hrly	Respirable Particulate Matter	mg/m^3	$\mu g/m^3$	Respirable Dust Sampler (RDS)
		Suspended Particulate Matter	mg/m^3	$\mu g/m^3$	High Volume Sampler (HVS)
2. Ambient Air Quality (AAQ) Monitoring	24 Hrly	Sulphur dioxide	ppm	$\mu g/m^3$	EPA modified West and Gaeke
		Nitrogen dioxide	ppm	$\mu g/m^3$	Modified Jacob and Hochheiser

3.3 Work-Place Emission Monitoring (WEM) at SIL, Amona, Goa

Temperature drop during flow of hot molten metal from blast furnace tap-hole to filling / pouring in mould assembly, leads to generation of graphite particulates / dust. It was, therefore, necessary to set up work place emission monitoring stations in pig iron production area of SIL. Work place emission monitoring for RPM, SPM, SO_2 and NO_2 was carried out in two, 8 Hrly shifts that is first during 07.00-15.00 hrs, second during 15.00-23.00 hrs. The monitoring equipments were installed inside pig iron production zone of M/s SIL at the following stations.

Work place emission monitoring stations:

1. Pig Casting Machine Area
2. Crane Control Room, BF-I
3. Crane Control Room, BF-II

3.3.1 WEM station No.1: Pig casting machine area

Table 3.2 depicts Concentration of Particulate Matter (PM) at installed station inside SIL during the study period (Oct 15-22, 2008). It is obvious from the table that, the average RPM and SPM value is 0.7 mg/m^3 and 2.2 mg/m^3. Statistical analysis of the data reflects that the 98^{th} percentile values of RPM and SPM are 0.9 mg/m^3 and 3.4 mg/m^3 and is within the prescribed work place environment ACGIH / OSHA standard of 10 mg/m^3 and 15 mg/m^3.

Table 3.2a represents gaseous emissions (SO_2 and NO_2). The average values of SO_2 and NO_2 are 4.0×10^{-3} ppm and 5.2×10^{-3} ppm respectively. During the study period, 98^{th} percentile values of SO_2 and NO_2 are 15.4×10^{-3} ppm & 7.4×10^{-3} ppm, which are well within OSHA standard of 5 ppm for work zone.

3.3.2 WEM station No. 2: BF-I area, SIL

The average RPM and SPM values at BF-I area are 0.8 mg/m^3 and 2.0 mg/m^3 (**Table 3.3)** during Oct 15-22, 2008. Statistical analysis of the data shows that the 98^{th} percentile RPM and SPM values are 1.1 mg/m^3 and 2.4 mg/m^3, which are well within ACGIH/ OSHA standard of 10 and 15 mg/m^3 for work zone during the study period.

Table 3.3a indicates that the average SO_2 and NO_2 values are 2.7×10^{-3} ppm and 2.4×10^{-3} ppm respectively, during the study period . However, 98^{th} percentile SO_2 and NO_2 values are 6.3×10^{-3} ppm and 4.1×10^{-3} ppm respectively, which are well within the OSHA standard of 5 ppm for work zone.

Table 3.2: Work Place Emissions - Particulate Matter Concentration at PCM Area, SIL

Monitoring Duration	RPM Concentration (mg/m^3)			SPM Concentration (mg/m^3)		
	07-15 Hr.	15-23 Hr.	Average	07-15 Hr.	15-23 Hr.	Average
Oct 15, 2008	0.85	0.51	0.68	5.27	1.82	3.55
Oct 16, 2008	1.02	0.42	0.72	2.53	1.14	1.83
Oct 17, 2008	0.69	0.51	0.60	2.42	1.14	1.78
Oct 18, 2008	0.96	0.62	0.79	2.76	2.67	2.71
Oct 19, 2008	1.01	0.56	0.78	1.89	1.15	1.52
Oct 20, 2008	1.54	0.38	0.96	2.01	1.97	1.99
Oct 21, 2008	0.58	0.36	0.47	1.98	1.70	1.84
Oct 22, 2008	0.95	0.71	0.83	2.15	2.07	2.11

Statistical parameters		
Minimum	0.5	1.5
Maximum	1.0	3.5
Average	0.7	2.2
Std. Deviation	0.2	0.7
98th percentile	0.9	3.4

ACGIH Indoor Regulatory Limit	**10 mg/m^3**	-
OSHA Indoor Regulatory Limit	-	**15 mg/m^3**
Percentage observations exceeding ACGIH / OSHA Indoor Regulatory Limit	All observations are within the permissible/prescribed limit.	

Table 3.2a: Work Place Emissions – Gaseous Concentration at PCM Area, SIL

Monitoring Duration	SO_2 Concentration (10^{-3} x ppm)			NO_2 Concentration (10^{-3} x ppm)		
	07-15 Hr.	**15-23 Hr.**	**Average**	**07-15 Hr.**	**15-23 Hr.**	**Average**
Oct 16, 2008	2.3	2.3	2.3	3.7	6	5.0
Oct 17, 2008	9.2	2.3	5.7	7.4	7	7.2
Oct 18, 2008	2.3	2.3	2.3	5.8	4	5.0
Oct 19, 2008	2.3	2.3	2.3	3.2	2	2.7
Oct 20, 2008	17.6	2.3	9.9	6.4	5	5.8
Oct 21, 2008	3.8	2.3	3.1	5.3	4	4.5
Oct 22, 2008	2.3	2.3	2.3	7.4	4	5.8

Statistical parameters		
Minimum	2.3	2.1
Maximum	17.6	7.4
Average	4.0	5.2
Std. Deviation	4.3	1.7
98th percentile	15.4	7.4

ACGIH / OSHA Indoor Regulatory Limit	**5 ppm**	**5 ppm**
Percentage observations exceeding ACGIH / OSHA Indoor Regulatory Limit	All observations are within the permissible/prescribed limit.	

Table 3.3: Work Place Emissions - Particulate Matter Concentration at BF-I Area , SIL

Monitoring Duration	RPM Concentration (mg/m^3)			SPM Concentration (mg/m^3)		
	07-15 Hr.	15-23 Hr.	Average	07-15 Hr.	15-23 Hr.	Average
Oct 15, 2008	0.61	0.60	0.61	3.31	1.63	2.47
Oct 16, 2008	1.34	0.95	1.14	2.12	1.77	1.95
Oct 17, 2008	0.70	0.59	0.65	1.83	2.01	1.92
Oct 18, 2008	0.68	0.58	0.63	2.26	1.89	2.08
Oct 19, 2008	0.97	0.59	0.78	3.25	0.92	2.08
Oct 20, 2008	0.69	0.52	0.61	1.64	2.08	1.86
Oct 21, 2008	0.77	1.03	0.90	2.27	2.17	2.22
Oct 22, 2008	0.86	0.96	0.91	1.68	1.93	1.81

Statistical parameters		
Minimum	0.6	1.8
Maximum	1.1	2.5
Average	0.8	2.0
Std. Deviation	0.2	0.2
98th percentile	1.1	2.4

ACGIH Indoor Regulatory Limit	**10 mg/m^3**	-
OSHA Indoor Regulatory Limit	-	**15 mg/m^3**
Percentage observations exceeding ACGIH / OSHA Indoor Regulatory Limit	All observations are within the permissible/prescribed limit.	

Table 3.3a: Work Place Emissions – Gaseous Concentration at BF-I Area , SIL

Monitoring Duration	SO_2 Concentration (10^{-3} x ppm)			NO_2 Concentration (10^{-3} x ppm)		
	07-15 Hr.	15-23 Hr.	Average	07-15 Hr.	15-23 Hr.	Average
Oct 16, 2008	2.6	2.3	2.4	2.3	1.6	1.9
Oct 17, 2008	2.3	2.3	2.3	3.2	2.7	2.9
Oct 18, 2008	2.3	2.3	2.3	1.6	2.1	1.9
Oct 19, 2008	2.7	2.3	2.5	1.6	1.6	1.6
Oct 20, 2008	2.3	7.6	5.0	1.6	2.7	2.1
Oct 21, 2008	2.3	2.3	2.3	4.3	3.7	4.0
Oct 22, 2008	2.3	2.3	2.3	2.7	1.6	2.1

Statistical parameters		
Minimum	2.3	1.6
Maximum	7.6	4.3
Average	2.7	2.4
Std. Deviation	1.4	0.9
98th percentile	6.3	4.1

ACGIH / OSHA Indoor Regulatory Limit	**5 ppm**	**5 ppm**
Percentage observations exceeding ACGIH / OSHA Indoor Regulatory Limit	All observations are within the permissible/prescribed limit.	

3.3.3 WEM station No. 3: BF-II area, SIL

Table 3.4 depicts concentration of Particulate Matter (PM) at installed station inside SIL during the study period (Oct 15-22, 2008). It is obvious from the table that, the average RPM and SPM value is 0.6 mg/m^3 and 1.9 mg/m^3. Statistical analysis of the data reflects that the 98th percentile RPM and SPM values are 0.8 mg/m^3 and 2.4 mg/m^3 which are less than the ACGIH / OSHA indoor regulatory limit of 10 mg/m^3 and 15 mg/m^3.

Table 3.4: Work Place Emissions - Particulate Matter Concentration at BF-II Area , SIL

Monitoring Duration	RPM Concentration (mg/m^3)			SPM Concentration (mg/m^3)		
	07-15 Hr.	**15-23 Hr.**	**Average**	**07-15 Hr.**	**15-23 Hr.**	**Average**
Oct 15, 2008	0.62	0.46	0.54	3.34	1.49	2.42
Oct 16, 2008	0.53	0.57	0.55	1.28	0.77	1.03
Oct 17, 2008	0.69	0.51	0.60	2.42	1.92	2.17
Oct 18, 2008	0.47	0.96	0.71	1.83	2.65	2.24
Oct 19, 2008	0.64	0.92	0.78	2.15	1.45	1.80
Oct 20, 2008	0.60	0.60	0.60	1.86	1.33	1.59
Oct 21, 2008	0.65	0.44	0.55	2.02	1.69	1.85
Oct 22, 2008	0.52	0.72	0.62	1.51	2.05	1.78

Statistical parameters		
Minimum	0.5	1.0
Maximum	0.8	2.4
Average	0.6	1.9
Std. Deviation	0.1	0.4
98th percentile	0.8	2.4

ACGIH Indoor Regulatory Limit	**10 mg/m^3**	-
OSHA Indoor Regulatory Limit	-	**15 mg/m^3**
Percentage observations exceeding ACGIH / OSHA Indoor Regulatory Limit	All observations are within the permissible/prescribed limit.	

Table 3.4a represents gaseous emissions for SO_2 and NO_2. The average values of SO_2 and NO_2 are 3.2×10^{-3} ppm and 4.7×10^{-3} ppm respectively which are well within the OSHA indoor regulatory limit of 5 ppm during Oct 16-22, 2008. However, 98^{th} percentile SO_2 and NO_2 values are 8.2×10^{-3} ppm & 7.3×10^{-3} ppm which are much below the OSHA indoor regulatory limit of 5 ppm.

Table 3.4a: Work Place Emissions – Gaseous Concentration at BF-II Area , SIL

Monitoring Duration	**SO_2 Concentration (10^{-3} x ppm)**			**NO_2 Concentration (10^{-3} x ppm)**		
	07-15 Hr.	**15-23 Hr.**	**Average**	**07-15 Hr.**	**15-23 Hr.**	**Average**
Oct 16, 2008	2.3	2.3	2.3	2.4	4	3.1
Oct 17, 2008	9.2	2.3	5.7	7.4	7	7.2
Oct 18, 2008	2.3	2.3	2.3	5.3	5	5.0
Oct 19, 2008	3.4	2.3	2.9	1.6	3	2.4
Oct 20, 2008	5.3	2.3	3.8	3.2	4	3.7
Oct 21, 2008	2.3	2.3	2.3	5.8	7	6.4
Oct 22, 2008	3.8	2.3	3.1	5.3	5	5.3

Statistical parameters		
Minimum	2.3	1.6
Maximum	9.2	7.4
Average	3.2	4.7
Std. Deviation	1.9	1.8
98th percentile	8.2	7.3

ACGIH / OSHA Indoor Regulatory Limit	**5 ppm**	**5 ppm**
Percentage observations exceeding ACGIH / OSHA Indoor Regulatory Limit	All observations are within the permissible/prescribed limit.	

3.4 Meteorology

Since meteorology plays an important role in dispersion of air pollutants, a study of micrometeorological parameters viz. wind speed, wind direction etc. as well as local topography, is necessary for deciding the location network of AAQ monitoring stations, as well as interpretation of AAQ results with respect to transport of pollutants from the identified source of air pollution. The micrometeorological data on hourly wind speed and wind direction during the monitoring period were collected from SIL, during Oct 13-22, 2008. **Fig. 3.1** presents "Wind rose" for the study period and depicts direction from which, the winds were blowing as well as its velocity range. Most of the times, wind speed was in the range of 1.8-3.6 Km/hr while a few observations were recorded in the range 3.6 - 7.2 Km/hr. Further, **Fig.3.1** reveals that most of the times (75%) winds were blowing from North-East sector to South-West sector (NE →SW).

3.5 Impact of Pig Iron Production Operations on Ambient Air Quality

Impact of fugitive emissions arising out of various material handling activities in pig iron production was assessed through Ambient Air Quality (AAQ) monitoring stations at eight identified sites within 10 km aerial distance around Sesa Industries Ltd. (SIL), Amona, Goa. **Table 3.5** presents the aerial distance as well as locations of eight AAQ monitoring stations with respect to SIL, Amona, Goa. Ambient air quality with respect particulate pollutants RPM and SPM and gaseous pollutants SO_2 and NO_2, the air quality was monitored during Oct 13-22, 2008 at the following identified sites:

Table 3.5: AAQ Monitoring around SESA Industries Ltd., Amona, Goa

Site No.	AAQ monitoring station	Approximate aerial distance from SIL (km)	AAQ site w.r.t. prominent wind-direction	Direction w.r.t. SIL
1.	Amona	01	Lateral (L)	North-West (NW)
2.	Cudnem	05	Upwind (UW)	North-East (NE)
3.	ICAR, Ella	10	Downwind (DW)	West-South-West (WSW)
4.	Boma	06	Downwind (DW)	South-South-West (SSW)
5.	Sanquelim	10	Upwind (UW)	North-East (NE)
6.	Betki-Khandola	04	Downwind (DW)	South (S)
7.	Sawai-Verem	08	Lateral (L)	South-South-East (SSE)
8.	Navelim	01	Lateral (L)	East -South-East (ESE)

Fig. 3.2 shows AAQ sites on the map of Goa as well as micrometeorological parameters (wind speed & direction) in the form of Wind Rose (**Fig. 3.1**), superimposed on the map.

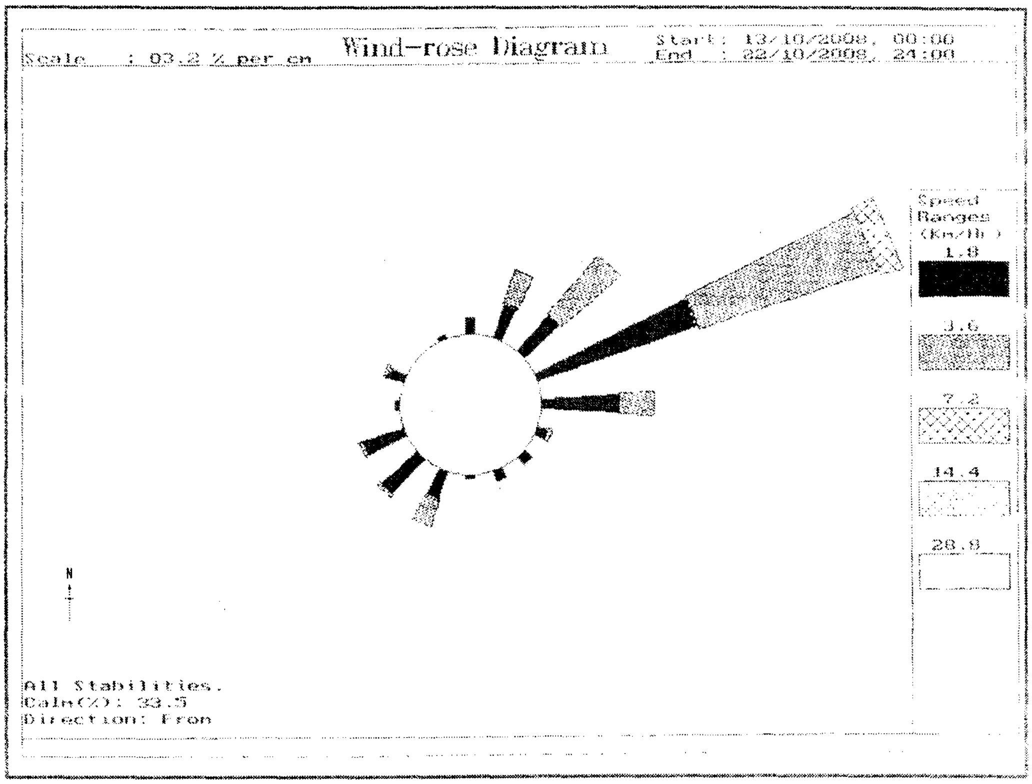
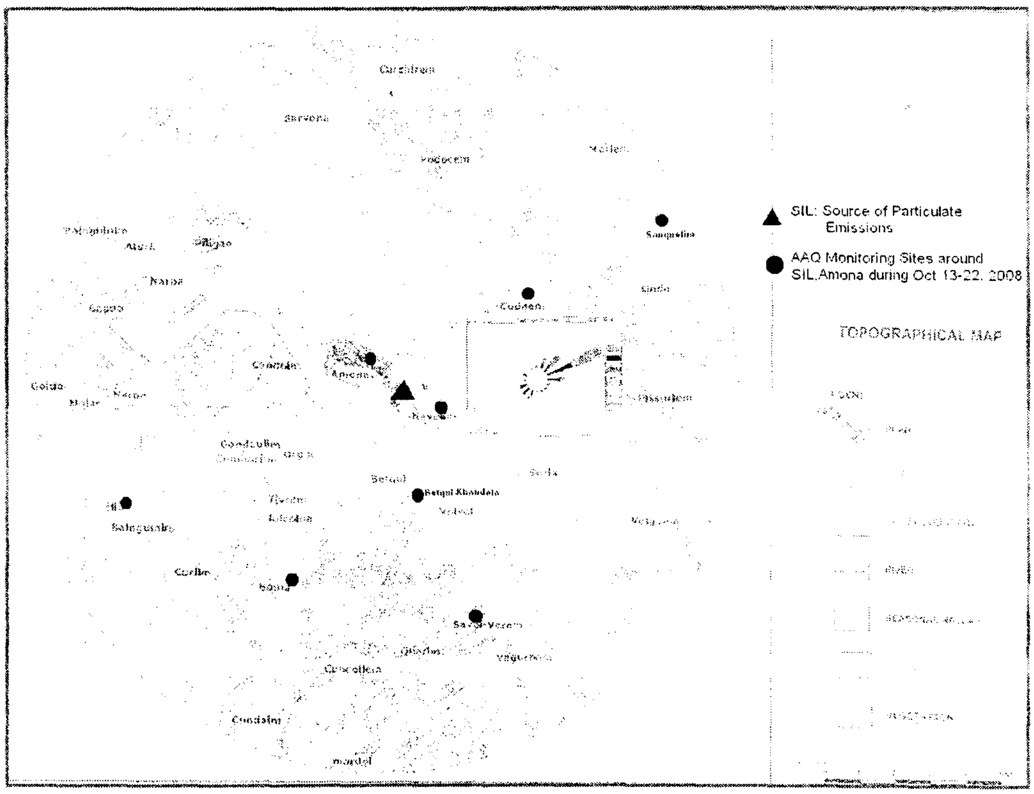


Fig. 3.1: Wind Rose at SIL, Amona ,Goa during Oct 13-22, 2008



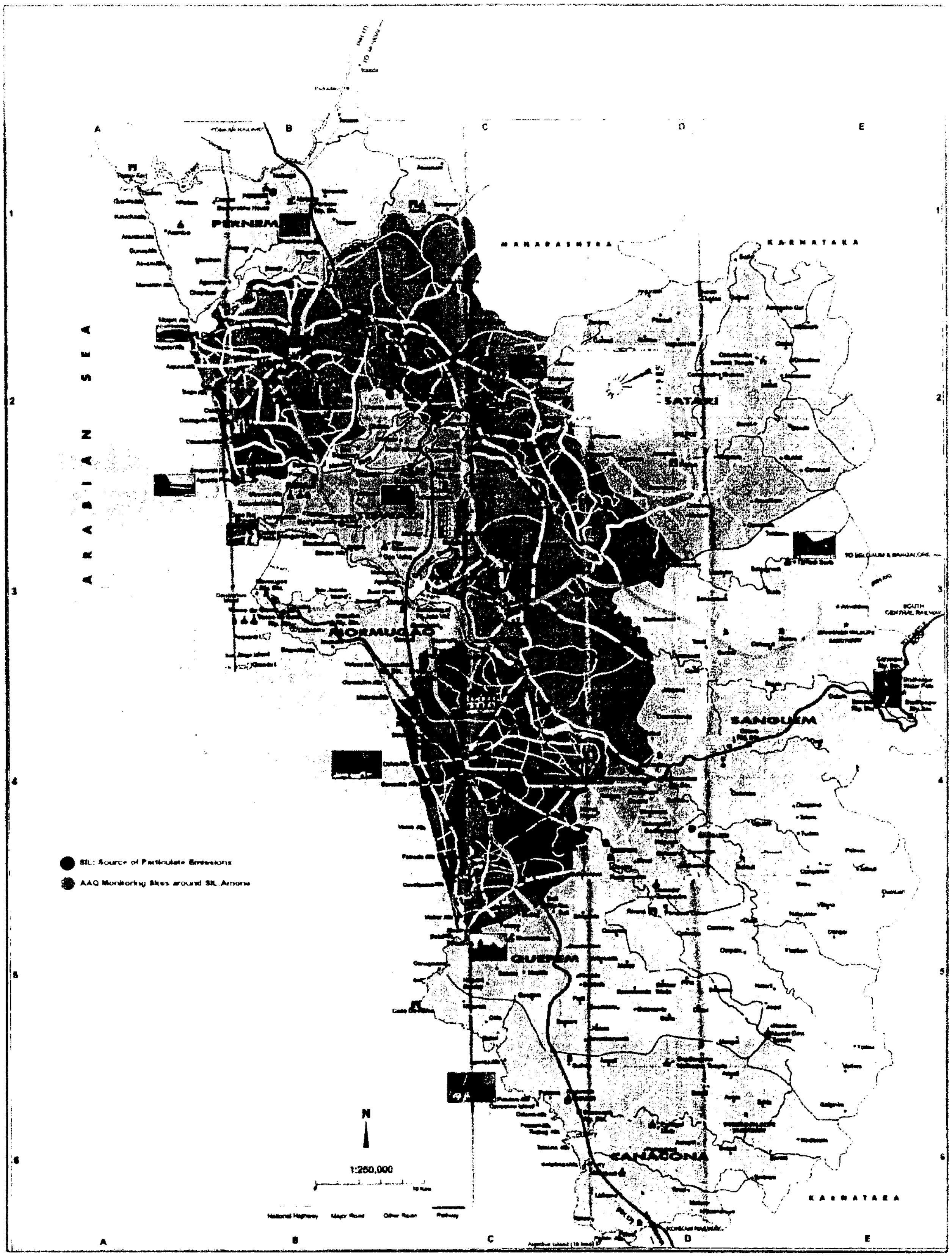


Fig.3.3: *Monitoring Sites on the map of Goa during Oct.13-22, 2008*

3.5.1 AAQM station No.1: Amona

Amona AAQM station is situated at about 1 km in North-West (NW) of SIL (**Fig. 3.2**). The samplers were kept on the open terrace (first floor) of a selected house (**Plate 3.1**). RPM, SPM, SO_2 and NO_2 were monitored during Oct 13-17, 2008. The data **(Table 3.6)** shows that, 24 hrly. average RPM, SPM, SO_2 and NO_2 values are within the GSPCB /CPCB prescribed standard of 100 µg/m^3, 200 µg/m^3 & 80 µg/m^3 respectively. The average RPM, SPM, SO_2 and NO_2 values were observed to be 70 µg/m^3, 93 µg/m^3, 6 µg/m^3 and 3 µg/m^3 respectively. **All observations are within the permissible limit.**

Table 3.6: AAQM Station No.1 :Air Quality at Amona

Monitoring Duration	Pollutant Concentration (µg/m^3)			
	SO_2	NO_2	RPM	SPM
Oct 13, 2008	6	4	85	87
Oct 14, 2008	6	3	86	119
Oct 15, 2008	6	3	73	86
Oct 16, 2008	6	3	59	87
Oct 17, 2008	6	3	48	86

Statistical parameters				
Minimum	6	3	48	86
Maximum	6	4	86	119
Average	6	3	70	93
Std. Deviation	0	0	17	15
98th percentile	6	4	86	116

CPCB / GSPCB Standard for Residential Area	**80 µg/m^3**	**80 µg/m^3**	**100 µg/m^3**	**200 µg/m^3**
Observations exceeding CPCB/ GSPCB Std. for Residential Area	All observations are within the permissible limit.			

3.5.2 AAQM station No.2: Cudnem

Mahalaxmi High School, Cudnem (**Plate 3.2**) is situated in the upwind direction and around 5 km North-East (NE) of SIL **(Fig. 3.2)**. AAQ monitoring results are shown in **Table 3.7.** It is observed that average values of RPM, SPM, SO_2 and NO_2 are 76 μg/m^3, 192 μg/m^3, 6 μg/m^3 and 5 μg/m^3 respectively. Although a few values of RPM and SPM are exceeding the stipulated standard, the average value of particulate concentration is within but close to AAQ standard of 100 μg/m^3 and 200 μg/m^3 respectively while gaseous pollutants are well within the AAQ standard of 80 μg/m^3.

In the study, 20% of the RPM and 20% of SPM observations are exceeding CPCB/ GSPCB standard of 100μg/m^3 and 200 μg/m^3 respectively for residential zone. The village being in upwind direction of SIL, Amona, the higher values are attributed to local anthropogenic activities.

Table 3.7: AAQM Station No.2: Air Quality at Mahalaxmi H.S., Cudnem

Monitoring Duration	**Pollutant Concentration (μg/m^3)**			
	SO_2	**NO_2**	**RPM**	**SPM**
Oct 13, 2008	6	6	91	117
Oct 14, 2008	6	6	**106**	**335**
Oct 15, 2008	6	8	52	169
Oct 16, 2008	6	3	48	185
Oct 17, 2008	6	4	82	155
Statistical parameters				
Minimum	6	3	48	117
Maximum	6	8	106	335
Average	6	5	76	192
Std. Deviation	0	2	25	84
98th percentile	6	8	105	323
CPCB / GSPCB Standard for Residential Area	**80 μg/m^3**	**80 μg/m^3**	**100 μg/m^3**	**200 μg/m^3**
Observations exceeding CPCB/ GSPCB Std. for Residential Area	0 %	0 %	20 %	20 %

Plate 3.1: RDS & HVS samplers for Air Monitoring at Amona

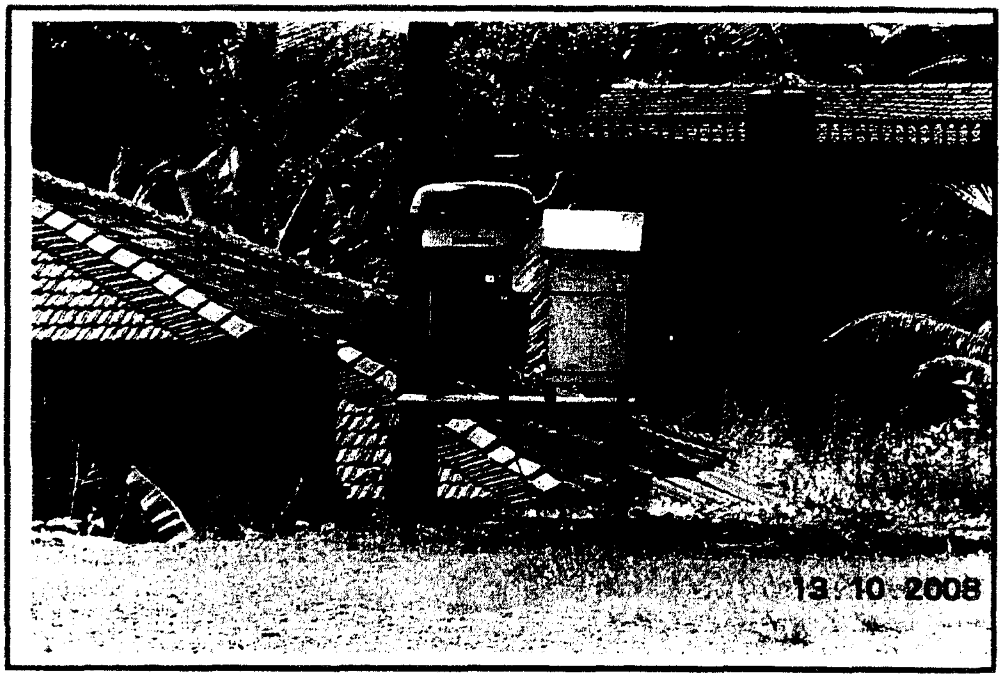


Plate 3.2: RDS & HVS samplers for Air Monitoring at Mahalaxmi H.S., Cudnem

3.5.3 AAQM station No.3: ICAR, Ella

ICAR, Ella (**Plate 3.3**) is situated in downwind direction, West-South-West (WSW) of and around 10 km away from SIL Plant (**Fig.3.2**). **Table 3.8** indicates the average values of RPM, SPM, SO_2 and NO_2 during study period (Oct 13-17, 2008) are 100 µg/m^3, 191 µg/m^3, 6 µg/m^3 and 17 µg/m^3 respectively. **All average values except RPM are within the GSPCB / CPCB prescribed standards for residential zone**. Gaseous pollutants SO_2 and NO_2 are well within the GSPCB / CPCB standards of 80 µg/m^3.

Statistical analysis reveals that, 80% of RPM and 40% of SPM observations exceeded the prescribed CPCB / GSPCB standard of 100 µg/m^3 & 200 µg/m^3 for residential zone. The higher values of RPM and SPM may be attributed to close proximity of sampling location to National highway-NH4A as well as local anthropogenic activities.

Table 3.8: AAQM Station No.3: Air Quality at ICAR, Ella

Monitoring Duration	Pollutant Concentration (µg/m^3)			
	SO_2	NO_2	RPM	SPM
Oct 13, 2008	6	6	**105**	124
Oct 14, 2008	6	16	**131**	**209**
Oct 15, 2008	6	33	**109**	**241**
Oct 16, 2008	6	11	**104**	188
Oct 17, 2008	6	20	49	193

Statistical parameters				
Minimum	6	6	49	124
Maximum	6	33	131	241
Average	6	17	100	191
Std. Deviation	0	10	30	43
98th percentile	6	32	129	238

CPCB / GSPCB Standard for Residential Area	**80 µg/m^3**	**80 µg/m^3**	**100 µg/m^3**	**200 µg/m^3**
Observations exceeding CPCB/ GSPCB Std. for Residential Area	0 %	0 %	80 %	40 %

3.5.4 AAQM station No.4: Boma

Fig.3.2 shows AAQ site, behind grampanchayat building, Boma (**Plate 3.4**) which is situated about 6 km in south-south-west (SSW), down wind direction of SIL, Goa. **Average RPM and SPM concentrations are 89 µg/m^3 and 166 µg/m^3 (Table 3.9) which are within respective GSPCB /CPCB standards of 100 µg/m^3 and 200 µg/m^3 for residential zone.** The SO_2 and NO_2 concentrations are within the prescribed standards of 80 µg/m^3 with an average value of 6 µg/m^3 and 4 µg/m^3 respectively.

In this case, 60% of RPM & 40% of SPM observations exceeded the prescribed CPCB/ GSPCB standard of 100 µg/m^3 & 200 µg/m^3 for residential zone.

The higher values of RPM and SPM may be attributed to close proximity of sampling location to National highway-NH4A as well as local anthropogenic activities.

Table 3.9: AAQM Station No.4: Air Quality at Behind Grampanchayat Building, Boma

Monitoring Duration	Pollutant Concentration (µg/m^3)			
	SO_2	NO_2	RPM	SPM
Oct 13, 2008	6	3	**122**	135
Oct 14, 2008	6	5	**131**	**227**
Oct 15, 2008	6	4	**108**	**231**
Oct 16, 2008	6	5	50	113
Oct 17, 2008	8	3	35	124

Statistical parameters				
Minimum	6	3	35	113
Maximum	8	5	131	231
Average	6	4	89	166
Std. Deviation	1	1	44	58
98th percentile	8	5	130	231

CPCB / GSPCB Standard for Residential Area	80 µg/m^3	80 µg/m^3	100 µg/m^3	200 µg/m^3
Observations exceeding CPCB/ GSPCB Std. for Residential Area	0 %	0 %	60 %	40 %

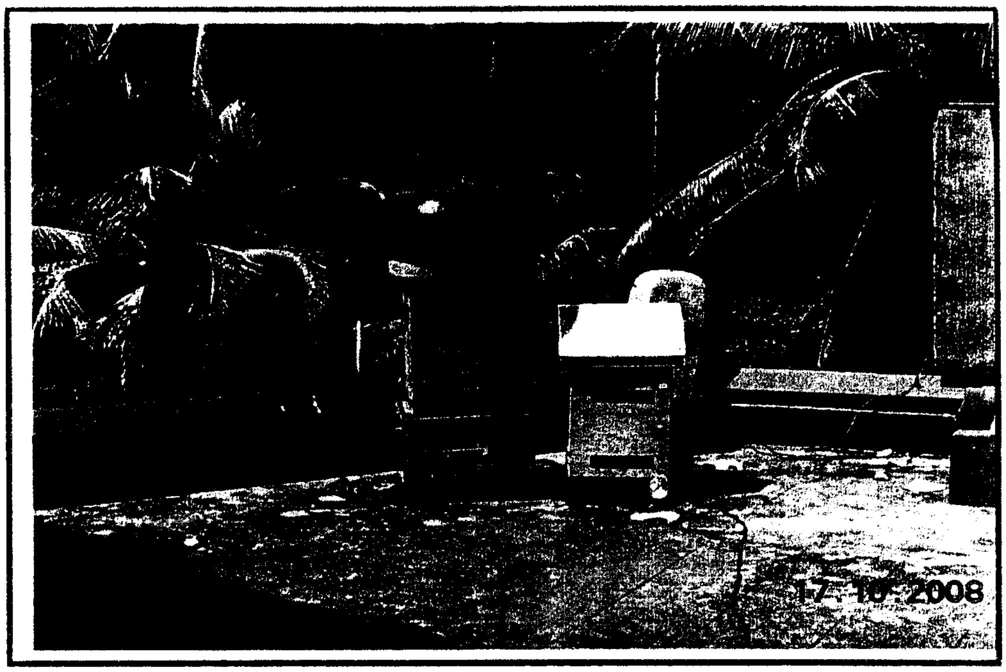


Plate 3.3: *RDS & HVS samplers for Air Monitoring at ICAR, Ella*

Plate 3.4: *RDS & HVS samplers for Air Monitoring at Behind Grampanchayat Building, Boma.*

3.5.5 AAQM station No.5: Sanquelim

Goa security agency building, Sanquelim **(Plate 3.5)** is situated in North-East (NE), upwind direction of and around 10 km away from SIL, Goa (**Fig.3.2**). AAQ monitoring results are presented in **Table 3.10. All the average concentrations of RPM, SPM, SO_2 and NO_2 are within prescribed CPCB / GSPCB standard of 100 µg/m^3, 200 µg/m^3 and 80 µg/m^3 for residential zone.**

Statistical analysis of AAQ data indicates that 20% of RPM values are exceeding the CPCB / GSPCB standard of 100 µg/m^3.

Table 3.10: AAQM Station No.5: Air Quality at Goa security agency building, Sanquelim

Monitoring Duration	Pollutant Concentration (µg/m^3)			
	SO_2	NO_2	RPM	SPM
Oct 18, 2008	6	4	52	107
Oct 19, 2008	6	3	**123**	171
Oct 20, 2008	6	3	86	160
Oct 21, 2008	6	3	94	147
Oct 22, 2008	6	4	79	131
Statistical parameters				
Minimum	6	3	52	107
Maximum	6	4	123	171
Average	6	3	87	143
Std. Deviation	0	1	26	25
98th percentile	6	4	121	170
CPCB / GSPCB Standard for Residential Area	**80 µg/m^3**	**80 µg/m^3**	**100 µg/m^3**	**200 µg/m^3**
Observations exceeding CPCB/ GSPCB Std. for Residential Area	0 %	0 %	20 %	0 %

3.5.6 AAQM station No.6: Betqui-Khandola

As shown in **Fig.3.2** Betqui-Khandola station is located in South (S) direction of and nearly 4 km away from SIL, Goa. The **Plate 3.6** projects the AAQ monitoring setup at the site. **Table 3.11** provides the concentrations of RPM, SPM, SO_2 and NO_2 and the respective average values during the study period are 63 µg/m^3, 144 µg/m^3, 6 µg/m^3 and 10 µg/m^3. **All the parameters are within the CPCB / GSPCB standard of 100 µg/m^3 & 200 µg/m^3 and 80 µg/m^3 respectively.**

Table 3.11: AAQM Station No.6: Air Quality at Betqui-Khandola

Monitoring Duration	Pollutant Concentration (µg/m^3)			
	SO_2	NO_2	RPM	SPM
Oct 18, 2008	6	12	68	131
Oct 19, 2008	6	10	27	93
Oct 20, 2008	6	11	47	161
Oct 21, 2008	6	15	95	161
Oct 22, 2008	6	4	77	172

Statistical parameters				
Minimum	6	4	27	93
Maximum	6	15	95	172
Average	6	10	63	144
Std. Deviation	0	4	26	32
98th percentile	6	15	94	171

CPCB / GSPCB Standard for Residential Area	**80 µg/m^3**	**80 µg/m^3**	**100 µg/m^3**	**200 µg/m^3**
Observations exceeding CPCB/ GSPCB Std. for Residential Area	All observations are within the limit.			

Plate 3.5: RDS & HVS samplers for Air Monitoring at Goa security agency Building, Sanquelim

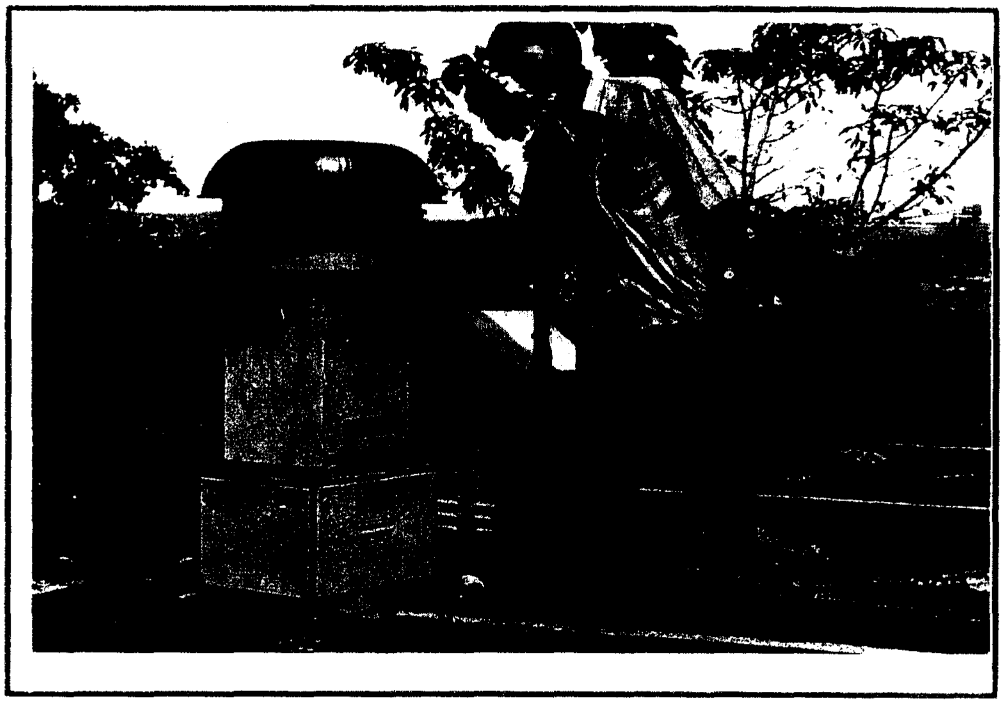


Plate 3.6: RDS & HVS samplers for Air Monitoring at Betki Khandola

3.5.7 AAQM station No.7: Sawai-Verem

Plate 3.7 shows AAQ station No.7 is located in South-South-East (SSE) direction, and nearly 8 kms away from SIL,Goa (**Fig.3.2**).

The average concentration of RPM and SPM are observed to be 44 µg/m^3 and 116 µg/m^3 (**Table 3.12**) respectively while the average concentration of SO_2 and NO_2 are 6 µg/m^3 and 4 µg/m^3 respectively. **All the parameters RPM, SPM, SO_2 and NO_2 are within the CPCB/ GSPCB standard of 100 µg/m^3, 200 µg/m^3, 80 µg/m^3 and 80 µg/m^3 respectively for residential zone.**

Table 3.12: AAQM Station No.7: Air Quality at Sawai-Verem

Monitoring Duration	Pollutant Concentration (µg/m^3)			
	SO_2	NO_2	RPM	SPM
Oct 18, 2008	6	3	25	72
Oct 19, 2008	6	3	40	107
Oct 20, 2008	6	3	41	130
Oct 21, 2008	6	4	58	142
Oct 22, 2008	6	5	54	130

Statistical parameters				
Minimum	6	3	25	72
Maximum	6	5	58	142
Average	6	4	44	116
Std. Deviation	0	1	13	28
98th percentile	6	5	58	141

CPCB / GSPCB Standard for Residential Area	80 µg/m^3	80 µg/m^3	100 µg/m^3	200 µg/m^3
Observations exceeding CPCB/ GSPCB Std. for Residential Area	All observations are within the limit.			

3.5.8 AAQM station No.8: Navelim

As shown in **Fig.3.2** Vividha H.S., Navelim station is located in East-South-East (ESE) direction, nearly 1 km away from SIL. The **Plate 3.8** depicts AAQ monitoring station. The **Table 3.13 projects the average concentration of RPM, SPM, SO_2, and NO_2 as 58 μg/m^3, 112 μg/m^3, 6 μg/m^3 and 4 μg/m^3 respectively which are within the CPCB/ GSPCB prescribed standard 100 μg/m^3, 200 μg/m^3, 80 μg/m^3 and 80 μg/m^3 respectively for residential zone**.

Table 3.13: AAQM Station No.8: Air Quality at Vividha H.S, Navelim

Monitoring Duration	Pollutant Concentration (μg/m^3)			
	SO_2	NO_2	RPM	SPM
Oct 18, 2008	6	4	50	93
Oct 19, 2008	6	3	66	127
Oct 20, 2008	6	5	67	125
Oct 21, 2008	6	5	67	148
Oct 22, 2008	6	4	39	65

Statistical parameters				
Minimum	6	3	39	65
Maximum	6	5	67	148
Average	6	4	58	112
Std. Deviation	0	1	13	33
98th percentile	6	5	67	146

CPCB / GSPCB Standard for Residential Area	80 μg/m^3	80 μg/m^3	100 μg/m^3	200 μg/m^3
Observations exceeding CPCB/ GSPCB Std. for Residential Area	All observations are within the limit.			

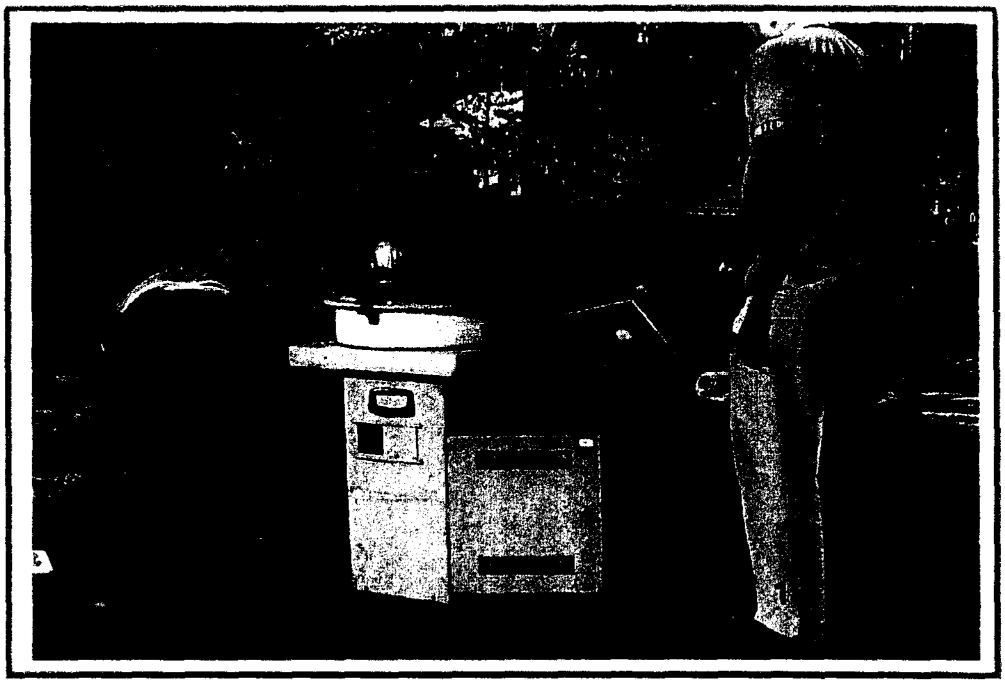


Plate 3.7: RDS & HVS samplers for Air Monitoring at Mr. Verenkar's home, Sawai-Verem

Plate 3.8: RDS & HVS samplers for Air Monitoring at Vividha H.S, Navelim

3.6 Site-wise Comparison of Particulate (SPM & RPM) and Gaseous (SO_2 & NO_2) Pollutant Levels vis-à-vis Regulatory Standards

Fig. 3.4 represents the work place air quality monitoring results for particulate matter and its compliance with ACGIH / OSHA indoor guidelines (**Annexure-II**). The average RPM (0.6 - 0.8 mg/m^3) and SPM (1.9 - 2.2 mg/m^3) concentrations at all monitoring stations are within ACGIH / OSHA indoor regulatory limits of 10 mg/m^3 and 15 mg/m^3 respectively for work place environment.

Fig. 3.5 represents the work place air quality monitoring results for gaseous pollutants and its compliance with ACGIH / OSHA indoor guidelines (**Annexure-II**). The average SO_2 (2.7 - 4.0 x 10^{-3} ppm) and NO_2 (2.4 - 5.2 x 10^{-3} ppm) values at all monitoring stations are within ACGIH / OSHA indoor regulatory limits of 5 ppm for work place environment.

Fig 3.6 indicates that average SPM value at all sites are within the CPCB / GSPCB standard of 200 µg/m^3, the highest average SPM value being 187 µg/m^3 found at Ella and Cudnem. The average RPM values at all sites except ICAR, Ella (103 µg/m^3) are within the CPCB / GSPCB standard of 100 µg/m^3 for residential zone.

Fig. 3.7 represents the gaseous emissions around the SIL. The average SO_2 and NO_2 concentrations are very low as compared to 80 µg/m^3 of CPCB / GSPCB standard. The highest NO_2 concentration being 19 µg/m^3 was found at Ella due to close proximity to National highway-NH4A.

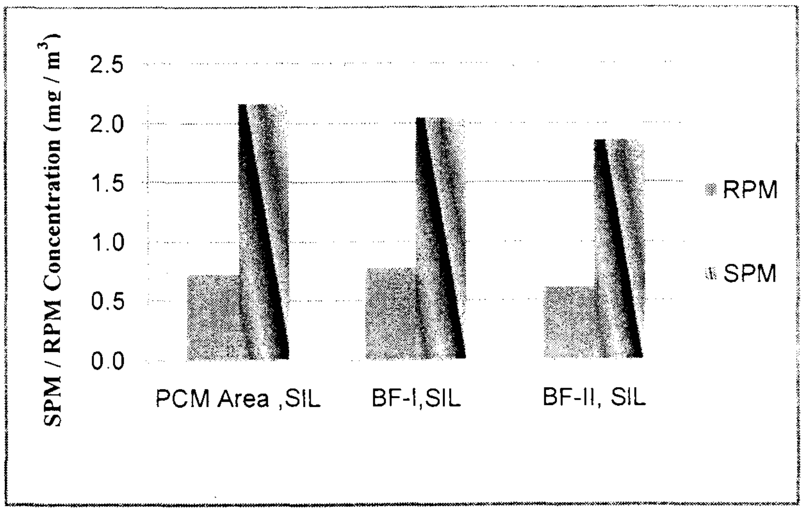
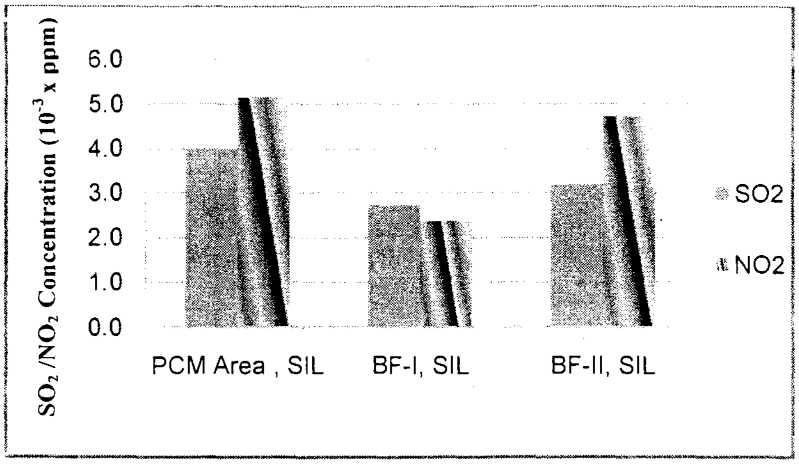


Fig.3.4: Location wise Avg. SPM /RPM Concentration (mg/m^3)

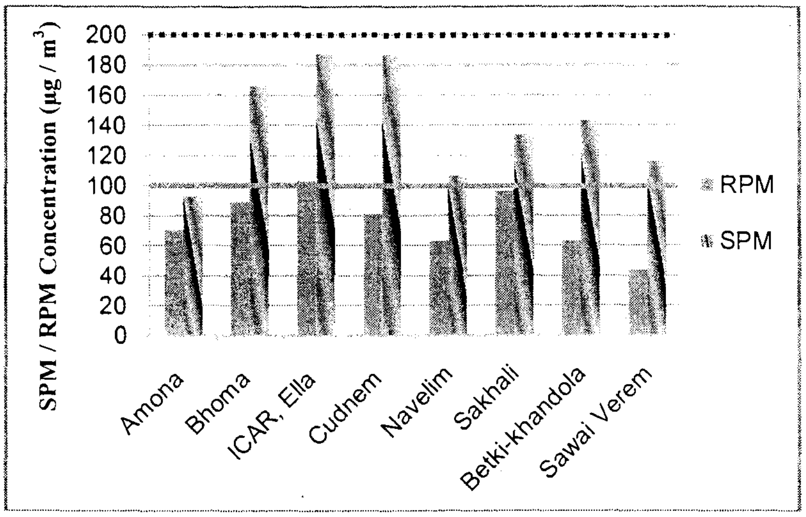
······ : CPCB /GSPCB standard for SPM –200 (µg /m^3)

▬▬ : CPCB /GSPCB standard for RPM –100 (µg /m^3)



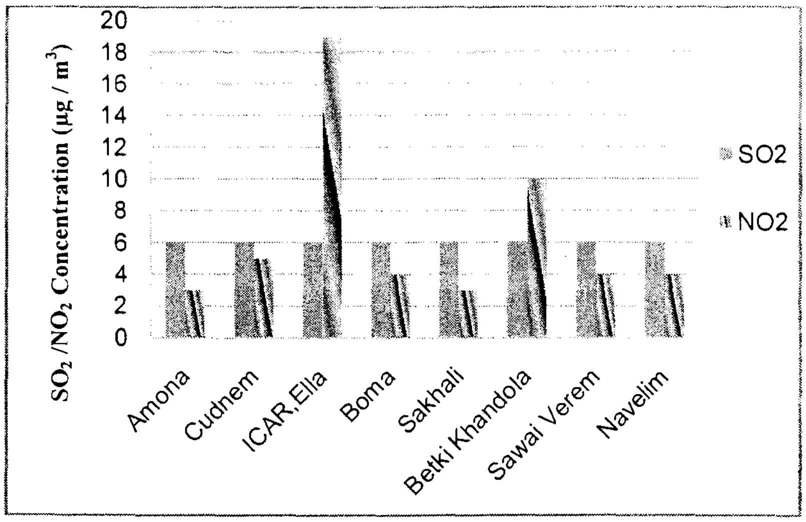
Monitoring locations at work place environment, SIL, Goa

Fig.3.5 : Location wise Avg. SO_2 /NO_2 Concentration (10^{-3} x ppm)



Monitoring Locations around SIL, Goa

Fig.3.6: Location wise Avg. SPM /RPM Concentration (µg/m^3)



Monitoring locations around SIL, Goa

Fig.3.7 : Location wise Avg. SO_2 /NO_2 Concentration (µg/m^3)

Chapter IV

Health Impact of Pig Iron Plant

Chapter IV

4.0 Health Impact of Pig Iron Plant

4.1 Introduction

A preliminary health survey was conducted to assess Health Impact(s) of Pig Iron Plant at Amona, Bicholim, Goa.The workers involved in production as well as the population residing in nearby villages were examined under this one time assessment program. It may be mentioned that a systematic study requires a time frame of around 6 months. However, preliminary findings can certainly be utilized for determining the need of conducting in depth health survey or otherwise.

4.2 Materials & Methods

Total 89 persons were examined 51 persons working in actual production plants were examined, whereas 38 persons from neighboring villages Amona and Naveli were examined. The workers from production plant were selected in approximately equal numbers from each shift. The village Panchayats of Amona and Naveli village were informed regarding this activity and they were given date and time for examination. The volunteers as sent by village Panchayats were examined. The examination included detailed history taking, complete general and systemic examination of the people. We also conducted pulmonary function tests on all persons. Pathological tests like Hemogram, ESR, LFT, KFT were done to evaluate effect on other body systems. Chest X– ray was advised in 29 persons. The patients were selected on basis of their examination findings. None of the patients produced significant amount of sputum required for examination.

The questionnaire used for collecting health related data is attached as **Annexure-III**

4.3 Review of Literature

The Pig Iron Production in Blast furnace release graphite dust, silica, carbon, manganese, phosphorus and traces of sulphur in the environment. The major concern is regarding graphite dust. A crystalline form of graphite "Kish" is deposited in iron furnaces from molten iron on cooling. In this process there is risk of exposure to inhalation of the particles.

4.3.1 Potential acute health effects of graphite

Slightly hazardous: In case of skin contact (irritant), eye contact (irritant), ingestion or inhalation.

4.3.2 Potential chronic health effects

The substance is toxic to upper respiratory tract and lower respiratory tract. The substances may be toxic to cardiovascular system, but there are no reports regarding the same. Repeated / prolonged exposure to the substances can produce target organ damage.

There is no data available on carcinogenic / mutagenic / teratogenic effect or any data regarding developmental toxicity. But carcinogenicity may be present.

4.3.3 Effect of graphite dust on respiratory tract

It may cause pulmonary fibrosis, emphysema or pneumoconiosis. These diseases may be aggravated with concomitant exposure to silicates.

The symptoms will usually be:

- Exertional dyspnoea
- Productive cough with black speckles
- Non-productive cough (fibrosis)

The examination will reveal:

- Altered breathing mechanics such as increase in respiratory rate, use of accessory muscles of breathing, naso-oral breathing.
- Barrel chest (emphysema)
- Pink puffers (emphysema)
- Digital clubbing (fibrosis) ,
- Prolonged expiration (COPD)
- Expiratory wheezing (COPD)
- Inspiratory crackles (fibrosis)

Radiographs of chest may show

- Barrel chest
- Nodular opacities (pneumoconiosis)
- Ground glass appearance (fibrosis)
- Hilar / mediastinal lymph nodes (fibrosis)
- Reticulation (pneumoconiosis)
- Honey combing (fibrosis)
- Pulmonary lymph nodes with sear formation (pneumoconiosis)
- Snow storm appearance with / without cavity (severe-pneumoconiosis)
- Basilar / sub pleural reticular opacities (fibrosis)

Spirometry may show

Emphysema

- Reduction in FEV_1
- Reduction in FEV_1 / FVC

- Reduction in Vital capacity
- Increase in residual volume
- Increase / Normal total lung capacity

Fibrosis

- Reduction in total lung capacity
- Reduction in Vital capacity
- Reduction in residual volume
- Normal / Increased FEV_1 / FVC

4.4 Health Status / Statistics

Following are the findings of data processed, for total number of 89 persons examined.

Sex (89)	Male	84	Females	5
Family disease history (11 / 89)	Diabetes Mellitus	2	Tuberculosi	1
	Ischemic heart	3	Ca lung	1
	Bronchial asthma	2	Hypertensio	2
Socioeconomic status	Lower middle class	22	Upper class	3
	Middle class	64		
Duration of exposure	< 5 yrs	9	16-20 yrs =	24
	6-10 yrs	7	> 20 yrs =	29
	11-15 yrs	20		
Proximity of residence from SIL	< 5 km	70	>11 km	5
	6-10km	14		
Skin disease (13 /89)	Psoriasis	2	Candidiasis	2
	Allergic dermatitis	8	Eczema	1
Ocular manifestations (5/89)	Eye irritation	3	Burning eye	2
Menstrual disturbances (5/89)	Menorrhagia	2	Menopausa	3
Chest pain (5/89)	Cramping pain	1	Right sided	1
	Could not describe	3		
Tobacco (4/89)	4			
Smoking (18/89)	18			
Alcohol (3/89)	3			
Acute Illness (7/89)	7 persons were suffering from recent cold and cough during the time of examination.			

Chronic diseases (27/89)	Diabetes mellitus-type 2: 4 / 89, Hypertension: 4 / 89, Arthritis 1/ 89, Bronchial asthma: 4/89, of which 1 person suffered during childhood but was normal in adulthood, spondylosis: 2/ 89, ischemic heart disease: 1/ 89, Acid peptic disease: 4/ 89, migraine:1/ 89, Headache: 1/ 89, ureteric calculi: 5/
Cough and Expectoration (15/89)	15 persons complained of cough of which one had it after smoking, and had also complained of nocturnal cough, eight persons had cough during winter, three persons had occasional history of cough, whereas three persons had chronic cough. Of these people, 9 persons produced sputum. One had doubtful hemoptysis, one had red-brown, one had black, one had yellow-white and 6 persons had white sputum.
Dyspnoea (4/89)	Present in four persons, of which on exertion in two, during routine work in one person and in one person due to protective mask.

4.4.1 Examination findings

Tachycardia was present in three people, hypertension was detected in 8 people, out of these 8, and only one was known hypertensive on treatment. Other three known hypertensive were well controlled with medications. Mild HT (130/90 – 140/90) was present in one; moderate HT (>140/90 – 150/100) was present in two and severe HT (>150/100) was present in five people.

Tachypnoea (Respiratory rate >20/ min) was present in 5 people. Harsh Breathing was present in two people, in one person there was prolonged expiration and crepitations were present in two people.

Rest systemic examination and general examination did not reveal any significant abnormality in any of the patients.

4.4.2 Investigations

Anemia	Present in 40 of 89 people, but it was borderline anemia, with Hb level ranging from 11-11.9 gm/dl which is not significant.
Total counts	normal in all people
Eosinophilia	(Eosinophils >4% on DLC) present in 16/89 people.
ESR	Raised in 23 people/89 people.
S creatinine	>1.7 in 3 people whereas mild elevation of SGPT was present in 3
Chest X- Ray	Performed in total 29 /89 people, no radiographic abnormality was detected in any case.
Lymphocytosis	>45% lymphocytes on DLC present in 43/89 people. Value is

Regarding the elevation of lymphocytes, following information is available

Normal Lymphocyte mean (%) found in various selected age ranges:

Age	Mean (%)	Age	Mean (%)
Adult	34	4 month-2 yrs	61
11-15 yrs	38	1-wk- 4 months	56
6-10 yrs	39	24 hrs-1 wk	24-41
4-6 yrs	42	First day of life	24
2-4 yrs	59		

Source: Clinical Diagnosis and management by laboratory method by Todd's.

4.4.3 Causes of Lymphocytosis

Lymphocytosis associated with small lymphocytes

Infectious lymphocytosis

- Mumps
- Varicella
- Rubella
- Herpes simplex
- Roseola infantum
- Viral illness
- Rickettsia
- Toxoplasmosis
- Pertusis
- Rubeola
- Atypical pneumonia
- Herpes Zoster
- Influenza
- T. B.
- Brucellosis

Lymphocytosis associated with atypical lymphocytes

- Infectious mononucleosis
- Post transfusion syndrome
- CMV
- Infectious hepatitis
- Hypersensitivity to PAS & phenytoin
- Infectious lymphocytosis
- Radiation

Other causes

- Letter sieve disease
- Lead intoxication
- L:ymhoma
- Post vaccination
- Agranulocytosis
- Leukemia
- Multiple myloma
- Collagen vascular disorder
- Stress

Uncommon causes

- Tertiary syphilis
- Smallpox
- Organic arsenical hypertensitivity
- Congenial syphilis
- Tetrachloroethane & trinitrotoluene poisoning
- Severe dermatitis herpetiformis

Therefore, this observation of elevated lymphocytes cannot be attributed to graphite exposure. The previous health records of patients are also not available for comparison.

4.4.4 Pulmonary function test

Pulmonary function test was done in all patients. Only one patient who was 68 yrs old and chronic smoker was not able to perform the test at all. Two patients could not perform the test satisfactorily.

FVC: Of the rest 86 people, predicted FVC was in normal range in all but in lower range of normal limits in three people. One of these patients was a female living in Amona village. She was totally asyM/s SlLomatic, clinical examination was normal and only mild electrons of ESR. Another patient was a young male resident of Amona village whose clinical examinations was normal and was asyM/s SlLomatic. He had mild lymphocytosis of 48%.

Third patient was a male of 38 yrs residing at Naveli village. He was asyM/s SlLomatic, a clinical examination was normal and investigations revealed mild lymphocytosis of 50% and high ESR (24 mm). His chest X-ray was also done which was normal.

Thus, there, was no significant correlations between the abnormal PFT findings and clinical profile of the patient.

FEV_1: Predicted FEV1 was normal in all 86 patients.

FEV/FVC: Predicted FEV1/FVC was also normal in all 86 patients.

PEF: Predicted PEF was low i.e. 68% in one patient who other than having mild eosinophilia of 8% was showing no evidence of any disease. He was a young male resident of Amona village. One more patient had PEF in lower limit of normal. This patient was a 50yrs old smoker working in blast furnace with 16yrs of exposure but rest of his clinical examination was normal, he was asymptomatic and his blood tests showed mild lymphocytosis (48%).

These abnormal PFT values do not have any significant correlation with clinical profile of the patients.

MVV: Predicted MVV was in normal range in all patients and one patient was unable to perform the test hence only 85 persons were examined.

Flow-volume curves revealed early obstruction in one patient.

Thus the PFT findings essentially do not correlate with any significant clinical abnormality.

4.5 Analysis

4.5.1 Correlation of smoking and disease

Total 18 patients accepted smoking, whereas 4 accepted tobacco chewing one person was addicted to both tobacco and cigarette smoking (total 21). All of them were males.

Exposure age to said pollutant of these people was as follows: none of them in group < 5 yrs, one in group 6-10 yrs, 10 in group 11-15 yrs, 5 in group 16-20 yrs and 5 in group > 21 yrs. Cough was present in 5 smokers of which one was smoking induced and nocturnal, whereas 2 had it in winter, one had occasional cough and one had blackish sputum, one had doubtful hemoptysis, two had white sputum. Dyspnoea was present in two of smokers whereas chest pain was present in three smokers. Investigations showed. Lymphocytosis in 11 people, eosinophilia in three people, and high ESR in two people. Chest X-ray of 7 smokers were done which were normal. Lung function tests could not be performed by two people, one person could not perform test for MVV, and one result was slightly abnormal i.e. his PEF was on the lower limit of normal.

Thus we do not get any specific information regarding any disease prevalence from this data.

4.5.2 Correlation (s) between exposure time and disease

Total number of patients exposed for < 5 yrs was nine. Of these, none of them were smokers one had history of childhood asthma but was asymptomatic in adulthood. He also had lymphocytosis and harsh breathing pattern. One of the patients had h/o cold induced Br. Asthma and h/o cough in winter. One of the patients had eosinophilia, and one more patient had lymphocytosis. The PFTs of patients were normal except one had low PEFR, one had low MVV, one had low FEV_1/FVC and one had low FVC, but all in normal range. Thus, no specific inference can be derived from this data.

There were total 7 people with exposure age of 6-10 yrs of which one was smoker. one patient suffered from recent cold, one had psoriasis, one had eczema, one had history of cough in winter. Examination was normal of all these patients. Lymphocytosis was present in three patients. PFT was normal in all.

Thus, no specific inference can be derived from this data.

There were total 20 people with exposure age of 11-15 yrs of these people 10 were smokers. One person's father had h/o Tuberculosis, but he did not have any positive findings except Lymphocytosis. There was history of cough in three people, chest heaviness in two, sputum production in one, skin irritation in one, eye irritation in one, acute upper respiratory infection in two people. Two had Hypertension, one had tachypnoea, SGPT was elevated mildly in one person, ESR was elevated in two people and lymphocytosis was present in 6 of 10 persons.

Thus, no specific inference can be derived from this data.

There were total 24 people with exposure age of 16-20 yrs of these 5 were smokers, three were known Diabetics, three were known Hypertensives. Two more hypertensives were newly diagnosed. Family history of IHD was present in two, of lung cancer in one, and Bronchial asthma in one patient. Acute U.R.I. was present in three patients. Cough was present in five people, of which one had recent cough due to URI and two had cough during winter. Expectoration was present in all five people. In one patient there was doubtful Haemoptysis. Dyspnoea was present in two patients, IHD was present in one patient. Tachycardia was found in one patient, Tachypnoea was found in one patient. Respiratory system examination revealed harsh breathing in one patient. Skin allergy was present in two people and one patient had psoriasis. Lymphocytosis was present in 16 people. Eosinophilia was present in four people and high ESR was found in three people. Chest X-ray was done in 10 patients all being normal. All PFTs were normal.

Thus, no specific inference can be derived from this data.

4.5.3 Correlation of exposure limits and disease

The entire study population was divided into two groups. One group was that of people working in the production plant itself, whereas the other group was of people (not working in production plant) living in the nearby villages of Amona and Naveli.

Total 51 people from production plant were examined, 26 people from Amona village and 12 people from Naveli village were examined.

Production plant (n =51)

Of these people, 11 were smoker/ used tobacco.

Exposure age < 5yrs was present in 9 people, 6-10yrs in 5 people, 11-15 yrs in 12 people and 15-20 yrs in 23 people.

6 people were suffering from acute Upper Respiratory Infections.

Cough was present in eight people of which, it was cold induced (winter) in four people, in one person it was smoking induced and in two people it was occasional and chronic cough was present only in one patient.

Only one patient had blackish expectoration and one patient had doubtful haemoptysis, but both of them could not produce sputum at the time of examination.

Dyspnoea was present in only one person.

Skin allergy was present in two people.

Hypertension was present in eight people and tachycardia in three people. Tachypnoea was present in five people.

Two patients had harsh breathing.

Rest systemic examination being normal.

Lymphocytosis was present in 28 people. Eosinophilia was present in 9 people. ESR was raised in 10 people.

Chest X-ray was done in 24 people which was normal.

Mild elevation of SGPT was present in four people. Mild elevation of S.creatinine was present in one case.

Slight reduction of predicted PEF% was present in one person, which was in Normal range. PFTs of rest of the people were normal.

No significant impact of graphite dust could be pointed out.

People in nearby villages (n=38)

There were 10 people who smoked/used tobacco.

10 of these people had stayed here < 15 yrs. Rests of the people were staying in these villages since their births. None of them suffered from any major acute illness, except one person having acute U.R.I.

Two patients were known cases of Bronchial asthma (controlled), one had hypertension and one had DM.

History of cough was present in seven people of which it was cold induced (winter) in four people, chronic cough in two people and occasional cough in one person. There was history of red-brown expectoration in one patient.

Dyspnoea was present in three people.

Skin allergy was present in fourpeople.

None of the patients had tachycardia or Hypertension at the time of examination.

one patient had vesicular breathing with prolonged expiration and scattered crepitations. He was a chronic smoker and clinically had COPD with Bronchiectasis. His chest X-ray could not be done and he was unable to perform spirometry.

One more patient had signs of Left Ventricular Failure.

Chest X-ray were done in five people which were normal.

Lymphocytosis was present in 16 people; eosinophilia was present in 7 people. High ESR was present in 13 people. S.creatinine was mildly elevated in two people.

Low PEFR was present in one patient, FVC at lower limit of normal was found in three people. One person had early obstruction on flow-volume curves.

No significant impact of graphite dust could be established.

Thus, there was no correlation between any specific disease process and the exposure limits. The diseases prevalent in both the groups (people in production plant and residents of nearby villages) were similar to those in general population.

Abbreviations:

COPD -Chronic Obstructive Pulmonary Disease

HT - Hypertension

FVC -Forced Vital Capacity

MVV -Minute Volume Ventilation

PEF -Peak Expiratory Flow

ESR -Erythrocyte Sedimentation Rate

URI -Upper Respiratory Tract Infection

Ca -Cancer

DLC- Differential Leukocyte Count

FEV -Forced Expiratory Volume

KFT - Kidney Function Test

LFT - Liver Function Test

PFT - Pulmonary Function Test

PEFR-Peak Expiratory Flow Rate

Chapter V

Conclusions

Chapter-V

5.0 Conclusions

5.1 Pig Iron Production

The production data provided by M/s SIL, Amona, Goa during study period indicates that on an average, the two blast furnaces together consume around 1100-1200 MTPD iron ore , 450-500 MTPD met coke, 15-20 MTPD nut coke, 100-110 MTPD lime stone, 60-70 MTPD dolomite producing around 800 MTPD pig iron, 16,00,000 Nm^3PD BF gas and 200 MTPD slag.

5.2 Work Place Environment

Work place emission monitoring of RPM, SPM, SO_2 & NO_2 was conducted in the vicinity of two blast furnaces at three sites, namely 1) Pig iron casting machine 2) Blast furnace No.I 3) Blast furnace No. II. The results indicate that 98^{th} percentile RPM / SPM values were well within ACGIH (10 mg/m^3) / OSHA (15 mg/m^3) respective standards for work place environment. Levels of gaseous pollutants SO_2 & NO_2 were also much below OSHA standard of 5 ppm (**Annexure-I**).

5.3 Ambient Air Quality

The results of AAQ monitoring conducted at eight villages within 10km radial distance from the plant reveal that the levels of gaseous pollutants SO_2 & NO_2 were well within the GSPCB/CPCB standards of 80 µg/m^3 for residential zone (**Annexure–II**).

All observations on RPM and SPM in four out of eight villages namely, Amona (1 km in NW), Navelim (1 km in ESE), Betqui-khandola (4 km in S) and Sawai-verem (8 km in SSE) direction of pig iron plant were well within respective GSPCB/CPCB standards of 100 µg/m^3 & 200 µg/m^3 for residential zone.

In respect of the villages Cudnem (5 km in NE) and Sanquelim (10 km in NE) where the impact of plant emissions is not likely to be observed, being located in the upwind direction of the plant, 40% and 20% of respective RPM observations exceeded the GSPCB / CPCB standards of 100 µg/m^3 for residential zone and 98^{th} percentile respective RPM value was 116 µg/m^3 and 121 µg/m^3 while in Cudnem 20% of the SPM observations exceed the GSPCB/CPCB standards.

The villages Boma (6 km in SSW) and Ella (10 km WSW) are both located in downwind direction of the plant and 98th percentile RPM value for both villages was 130 µg/m^3. 60% and 40% of total RPM observations in the villages Boma and Ella respectively exceed GSPCB / CPCB standards of 100 µg/m^3. 40% of the SPM observations exceeded the GSPCB / CPCB standards of 200 µg/m^3 while 98th percentile SPM values at the respective villages were 231 µg/m^3 and 238 µg/m^3. High values of RPM and SPM in villages Boma and Ella, situated around 6 km and 10 km respectively in down wind direction of the plant, may be attributed to close proximity of sampling locations with national highway (NH) 4A as well as local anthropogenic activities.

5.4 Impact of Particulate Emissions from Pig Iron Plant on Human Health

Total 89 persons were examined. 51 persons working in actual production plants, whereas 38 persons from nearby villages Amona and Navelim, were examined. There was no specific increased prevalence of respiratory illness/ skin/ ocular allergies/evidence of heart disease in people involved in production plant or in nearby villages. The acute / chronic illness present in study population was similar to such illnesses in general population and cannot be correlated with occupational conditions prevailing at the time of conducting the study. The examination findings did not also reveal any specific disease pattern. The chest X-ray and spirometry of the study population also did not reveal any significant disease pattern. However, the blood tests showed lymphocytosis in 43/ 89 adult persons, which was abnormal (>45%). Overall health status of the study population was fairly good.

However, this is a onetime health impact study and to carry out a rigorous assessment, such study should be carried out with statistically designed experiments which in the instant case may not be required.

Thus, this study does not point out any obvious disease related to graphite exposure.

Chapter VI

Recommendations
for
Air Environment Management Plan

6.0 Recommendations for Air Environment Management Plan

Major sources of particulate pollution in pig iron production are raw materials handling, crushing, screening, material transfer through conveyors/ junctions points, charging, coke oven unit, blast furnace unit , product and by-product handling, etc.

6.1 Raw Materials Handling

Iron ore is transported to storage yard by trucks/tipper and stacked over open space. Coal from vessels/ship is transported by barges to M/s SIL's Jettys and stocked in closed coal shed by trucks. Raw materials which include iron ore, coal, coke and fluxes such as limestone and dolomite are transported within plant area by belt conveyors. Depending on the state of the material, the height from which the material is dropped, its moisture content, as also weather conditions, etc. the material being handled generates dust to a greater or lesser degree. Thus, the particulate emissions are generated as a result of material handling and transfer operations. Following short and long term measures may be adopted, wherever applicable, in order to reduce particulate dust emissions.

Short term measures:

- Height of raw material stockpile on the open plot may be restricted to 5m.
- The dusty materials, stock piled on open plots should always be adequately covered with tarpaulin / HDPE sheets.
- Mobile/fixed wind shields / screens around raw materials stocked on open plots, may be installed with adjustable (sliding) arrangement up to 9 meter height.
- Wherever necessary, spray nozzles may be installed and operated during material transfer operations, in order to minimize wind erosion of loose/fine particles and resulting particulate pollution in the surrounding air basin.
- The trucks/tippers should not be allowed to overload with dusty raw materials. The loaded trucks may be sprayed with water and adequately covered with tarpaulin / HDPE sheets. Transporters may be advised to ply trucks / tippers within permissible speed limit during in-plant transportation.
- For suppression of re-suspended dust particulates during in-plant material transfer operations, the current practice of water spray on roads may be continued.

- Whenever material transfer operations on open space are in progress, mobile overhead collection hood connected to dust scavenging system be installed.
- All dusty raw material handling / transfer operations may be temporarily suspended during very strong/gusty winds.

Long term measures:

- In absence of adequate number of closed storage sheds, M/s SIL may install closed belt conveyer system to transfer dusty materials from stocks on open plots directly to charging bins/hoppers.
- M/s SIL may undertake construction of additional sheds for storage of iron ore in phased manner as soon as possible.
- All the dusty material handling / transfer operations, as far as possible, may be conducted in properly enclosed areas under negative pressure, and the dusty gas thus evacuated, be passed through particulate emission control devices.

6.2 Blast Furnace Gas

The blast furnace gas normally comprises approximately 23-24% Carbon monoxide (CO), 2-4% Hydrogen (H_2), 20-22% Carbon Dioxide (CO_2) and the rest 50-55% Nitrogen (N_2).

- Since, BF gas has high CO content, which is poisonous as well as combustible, M/s SIL may provide adequate number of CO monitors as well as spark arresters at critical locations of BF gas supply, in order to eliminate the risk of accident.
- Fire extinguishers may be installed at prominent as well as handy locations.

6.3 Cast House Emissions

Cast house emissions are released while handling molten metal and originate right from molten metal flow from tap hole of blast furnace through runners extended to receiving ladles/troughs, pouring of molten metal into moulds and stacking/loading of pig iron blocks, *etc*. The major factors which govern the magnitude of cast house emissions are the size (capacity) of blast furnace, type and quality of pig iron, the slope and dimensions of runners, free-fall height of molten metal above ladle, temperature of molten metal, *etc*. The fume emissions are released as a direct result of exposure of molten metal to air and its oxidation, as well as vaporization of alkali oxides from slag during its run off from furnace through runners into troughs / ladles. When exposed to atmosphere, drop in temperature of hot molten metal, leads to crystallization of the graphite particles/flakes from supersaturated molten metal, resulting in emissions of carbon particles (graphite flakes). Combustion of impregnated tars/resins in refractory clays also results in fugitive emissions.

Work-place cast-house emissions may be effectively controlled through following measures:-

- Optimum operating conditions viz. charging of iron ore, coke, fluxes etc. flow rate and circulation of hot air blast, furnace combustion temperature, rate of molten metal withdrawal from BF and its pouring into moulds etc. may be maintained.
- Extraction / evacuation of generated fumes / particles through movable collection hoods connected to particulate control devices (High efficiency multi cyclones /bag filters/electrostatic precipitator, etc.) through ID fans.
- Although, the particulate levels in the work zone are within OSHA/ACGIH standards, M/s SIL may consider installation of an improvised efficient, mobile fugitive dust collection hood connected to particulate emission control system to further reduce the nuisance of cast house emissions to nearby habitats.
- As an additional measure, roof top collection hoods with higher suction capacity may be installed, to take care of instantaneous / accidental release of fumes/ particulate emissions generated in an event of sudden break-down / malfunction of any unit.
- Mobile wind shields / screens of suitable height may be erected and placed in downwind direction outside the cast house unit, so as to hinder dispersion of graphite particles outside the unit.
- M/s SIL may install such wind shields / screens along the plant boundary facing villages Amona and Navelim so that prevailing nuisance of graphite dust to the villagers, may be reduced.

6.4 Health Safety and Environment (HSE) Aspects

- It may be made mandatory for all the shop floor employees working in pig iron production zone to wear gas masks, spectacles, helmet, protective clothes, Industrial boots, etc.
- Training program for shop floor workers, at regular intervals may be conducted to impart training on various aspects of health safety and environment as well as vigilance to deal with any emergencies / accidents.
- Surprise mock-drills of shop floor may be conducted to assess the level of awareness to handle such situation.

6.5 Corporate Social Responsibility (CSR) Aspects

- Apart from providing community hall and employment to deserving youths of the villages, Amona and Navelim, M/s SIL may consider providing basic amenities as required by the villagers under community development program.
- Health camps for routine check-up as well as for specific ailments on villager's request be arranged periodically.
- M/s SIL may initiate some schemes under Public Private Partnership (PPP) program to provide incentives to the deserving / aspiring villagers.

Annexure

Guideline values for indoor air pollutants

	Enforceable and/or Regulatory Levels			Non-enforced Guidelines and Reference Levels			
	NAAQS/EPA (ref. A-1)	OSHA (ref. A-2)	MAK (ref. A-3)	Canadian (ref. A-4)	WHO/Europe (ref. A-5)	NIOSH (ref. A-6)	ACGIH (ref. A-7)
Carbon dioxide		5,000 ppm	5 000 ppm 10,000 ppm [1hr]	3,500 ppm [L]		5,000 ppm 30 000 ppm [15min]	5,000 ppm 30,000 ppm [15min]
Carbon monoxide [e]	9 ppm [g] 35 ppm [1hr] [g]	50 ppm	30 ppm 60 ppm [30min]	11 ppm [8hr] 25 ppm [1hr]	90 ppm [15min] 50 ppm [30min] 25 ppm [1hr] 10 ppm [8hr]	35 ppm 200 ppm [C]	25 ppm
Formaldehyde [h]		0.75 ppm 2 ppm [15min]	0.3 ppm 1 ppm] [f]	0.1 ppm [L] 0.05 ppm [L] [b]	0.1 mg/m³ (0.081 ppm) [30 min] [e]	0.016 ppm 0.1 ppm [15min]	0.3 ppm [C]
Lead	1.5 µg/m³ [3 months]	0.05 mg/m³	0.1 mg/m³ 1 mg/m³ [30min]	Minimize exposure	0.5 µg/m³ [1yr]	0.1 mg/m³ [10h]	0.05 mg/m³
Nitrogen dioxide	0.05 ppm [1yr]	5 ppm [C]	5 ppm 10 ppm [5min]	0.05 ppm 0.25 ppm [1hr]	0.1 ppm[1hr] 0.004 ppm [1 yr]	1 ppm [15min]	3 ppm 5 ppm [15min]
Ozone	0.12 ppm [1hr] [g] 0.08 ppm	0.1 ppm	[f]	0.12 ppm [1hr]	0.064 ppm (120 µg/m³) [8hr]	0.1 ppm [C]	0.05 ppm [k] 0.08 ppm 0.1 ppm [m] 0.2 ppm [n]
Particles [e] <2.5 µm MMAD [d]	15 µg/m³[1 yr] [e] 65 µg/m³ [24 hrs] [e]	5 mg/m³	1.5 mg/m³ for <4 µm	0.1 mg/m³ [1hr] 0.040 mg/m³ [L]			3 mg/m³
Particles [e] <10 µm MMAD [e]	50 µg/m³[1 yr] [e] 150 µg/m³ [24 hrs] [e]		4 mg/m³				10 mg/m
Radon	See Table 3 [f]				2.7 pCi/L [1yr]		
Sulfur dioxide	0.03 ppm [1yr] 0.14 ppm [24hr] [g]	5 ppm	0.5 ppm 1 ppm [f]	0.38 ppm [5min] 0.019 ppm	0.048 ppm [24h] 0.012 ppm [1yr]	2 ppm 5 ppm [15min]	2 ppm 5 ppm [15min]
Total Particles [e]		15mg/m³					

Source: Indoor Air Pollutants, Hal Levin, LBNL (Ventilation Information Paper 02, Dec 2003)

CENTRAL POLLUTION CONTROL BOARD

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS) NOTIFICATION
Delhi, 11 April, 1994 and October 14, 1998

S.O. 384(E) and S.O. 955(E) - The Central Pollution Control Board in exercise of its powers conferred under section 16(2) (b) of the Air (Prevention and Control of Pollution) Act, 1981 (14 of 198) hereby notify the National Ambient Air Quality Standards with immediate effect.

Schedule-1

Pollutant	Time weighted Average	Concentration in ambient air			Method of measurement
		Industrial Area	Residential Rural/Mixed Area	Sensitive Area	
Sulphur Dioxide (SO_2)	Annual Average* 24 hours**	80 µg/m³ 120 µg/m³	60 µg/m³ 80 µg/m³	15 µg/m³ 30 µg/m³	-Improved West & Gaeke -UV-fluorescence
Oxides of Nitrogen (NO_2)	Annual Average* 24 hours**	80 µg/m³ 120 µg/m³	60 µg/m³ 80 µg/m³	15 µg/m³ 30 µg/m³	-Jacob & Hochheiser modified (Na-Arsenite) Method -Gas phase chemillumine-scence Method
Suspended Particulate Matter (SPM)	Annual Average* 24 hours**	360 µg/m³ 500 µg/m³	140 µg/m³ 200 µg/m³	70 µg/m³ 100 µg/m³	-High Volume Sampling (Average flow not less than 1.1 m³/minute)
Respirable Particulate Matter [size <10 um] (RPM)	Annual Average* 24 hours**	120 µg/m³ 150 µg/m³	60 µg/m³ 100 µg/m³	50 ug/m³ 75 ug/m³	-Respirable particulate matter sampler
Lead (Pb)	Annual Average* 24 hours**	1.0 µg/m³ 1.5 µg/m³	0.75 µg/m³ 1.00 µg/m³	0.50 µg/m³ 0.75 µg/m³	-AAS Method after sampling using EPM 2000 or equivalent filter paper
Carbon Monoxide (CO)	8 hours** 1 hour	5.0 mg/m³ 10 mg/m³	2.0 mg/m³ 4.0 mg/m³	1.0 mg/m³ 2.0 mg/m³	-Nondispersive infrared spectroscopy
Ammonia	Annual Average 24 hours**	100 µg/m³ 400 µg/m³	100 µg/m³ 400 µg/m³	100 µg/m³ 400 µg/m³	-

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval

** 24 hourly/ 8 hourly values should be met 98% of the time in a year. However, 2% of the time it may exceed but not on two consecutive days.

Note:
1. National Ambient Air Quality Standard: The levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property
2. Whenever and wherever two consecutive values exceed the limit specified above for the respective category, it would be considered adequate reason to institute regular / continuous monitoring and further investigations
3. The State Government/State Board shall notify the sensitive and other areas in the respective states with in a period of six months from the date of Notification of National Ambient Air Quality Standards
4. The above standards shall be reviewed after five years from the date of notification.

Source: [S.O. 384(E), Air (Prevention & Control of Pollution) Act, 1981, dated April 11, 1994]
[EPA Notification: GSR 176 (E), April 02, 1996]

Questionnaire

Date:

Rapid Environmental Impact Assessment of Pig Iron Plant at Amona Bicholim, Goa

1. Name
2. Male/ Female
3. Age
4. Health status
5. Religion & caste
6. Maritial status (Married / Unmarried) Individual Mother/ Father
7. Family status (No. of dependent)
8. Food habits (Veg/ Non-veg)
9. Habits (Smoker/Non smoker/Alcohol)
10. Cigareette/Tobacco (ConsuM/s SILion/day/week/month)
11. Alcohol (ConsuM/s SILion/day/week/month)
12. Weight and height
13. Social status (Upper class/Middle class/ lower Middle class)
14. Exposure source
15. Exposure limits (0-8hrs)

    Long term exposure limits (more than 8 hrs)
16. Exposure Age

    5-10 years
    10-15 years
    15-20 years
    > 20 years
17. Residence proximity to industrial source
18. Name of the industry
19. Duration of working shifts
20. Earning members
21. Income scale
22. Previous family history with respect to death of any related to genetic disorder (cancer/diabetes/or any other)/ any family member suffering from any chronic disease
23. Prevailed acute disease, if any
24. Prevailed chronic disease, if any

25. Respiratory tract disorder
(whether subject feels of breathing disorder)
Cough: Yes / No

if Yes, - Duration

Nocturnal cough Yes / No

- Sputum Yes / No

Yes -Colour ________

Shortness of Breath/ Breathlessness Yes / No - at rest

- at night

- on coughing

- on exertion

on routine work

Chest pain- Yes/No
if Yes, Associated with

- Cough Yes/No
- Breathlessness Yes/No

Smoking Yes/No

Uneasiness Yes/No

26. Cardiac disorder (Previous or present)
27. Hamatological disorder (Previous or present)
28. Haemoglobin level
29. Hepatocytic disorder (Previous or present)
LFT
30. Renal disorder (Previous or present)
KFT
31. Allergic reactions (previous or present) (skin)
32. Reasons for allergic reactions
33. Irritations in skin/eye
34. Menstrual disturbances
35. Abortion/Preterm delivery
36. Still Birth
37. Developmental abnormality in fetus
38. Medication history

Examination

- Pulse rate –
- B.P. –
- Resp. rate at rest –
- Sp O_2 at rest –
- Chest inflation –
- Cyanosis - +/-
- JVP – N/↑
- Oedema - +/-
- Clubbing - +/-
- Skin pigmentation changes - +/-
- R/s – type of Breathing, Extra sounds
- CVS-
- P/A -

Investigations

- Hb
- TLC
- DLC
- ESR
- Sputum - X^n
- Chest X-ray
- Renal function test
- Liver function test
- PFT